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EFFECT OF PULLORUM DISEASE ON DISTRIBUTION OF FIRST YEAR EGG PRODUCTION.

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In an earlier report (*1*) it has been shown that hens which react positively to the agglutination test for pullorum disease lay fewer eggs, on the average, than those that react negatively to this test. The difference in average egg production was so great that it was considered desirable to secure additional information, not only with regard to the total number of eggs laid, but also with regard to the distribution of eggs laid during the first year. Such information is now available for two successive years.

For the present study the records of 689 hens were used. The data were obtained from six different breeds—S. C. White Leghorns, S. C. R. I. Reds, B. P. Rocks, White Wyandottes, Light Sussex and Black Orpingtons. The eggs from the different breeds were hatched in the same incubator or incubators and brooded together under the same hover. The birds were reared together on range and were housed and fed alike during their first laying year. No culling was done after the birds were placed in the laying houses. Records of all birds that survived to the end of the first laying year were included to make up the total of 689 records.

The birds hatched in 1926 were tested once by the agglutination test at the end of their first laying year. Those hatched in 1927 were tested three times: once at the beginning of the laying year; again at the middle of the year, in May; and the last time, in the latter part of October, towards the end of their first laying year.

Egg Production of Birds that Did and Did Not React at the End of the First Laying Year

The records obtained, classified according to the results of the tests at the end of the laying year, will be considered first. Tables 1 and 2, it may be noted, include records presented in similar tables in a previous report (*1*) in addition to 331 records obtained in 1927-28.

First Year Egg Production

The data for total first year egg production are presented in table 1. One hundred and two out of six hundred and eighty-nine birds, or 14.8 per cent, reacted positively to the agglutination test for *S. pullorum*. This is less than the percentage in 1926-27, due to a slightly lower proportion of reactors in 1927-28. The percentage of reactors among the different breeds varied from 5.8 per cent in the case of the S.C. White Leghorns to 33.3 per cent in the case of the Black Orpingtons. The percentage of reactors

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among the Leghorns was consistently low in both years, but varied in the case of the other breeds. No significance, however, can be attached to these variations on account of the small number of birds of some breeds. At the same time, it may be noted that the lower percentage of reactors among the S. C. White Leghorns as compared with other breeds agree with the results reported elsewhere (*2, 3, 4, 5*).

Considering first the egg production of reactors and non-reactors by breeds, as set forth in table 1, it will be noted that the average, or mean, egg production of the reactors was in every case considerably lower than that of the non-reactors. The differences varied from 37.89 eggs in the case of the Light Sussex to 60.58 eggs in the case of the Black Orpingtons. Among the other breeds, the total first year egg production of the reactors was from 42 to just under 60 eggs less than that of the non-reactors. These differences are all statistically significant.

The mean first year egg production of all the non-reactors was 221.68 eggs, while that of 102 reactors was 160.09 eggs, a difference of over 61 eggs. This difference in the first year egg production of reactors and non-reactors is made a little greater than would be expected by their distribution among the various breeds. Thus 178 or 30.3 per cent of the non-reactors, as compared with 11 or 10.8 per cent of the reactors, were Leghorns. On the other hand, in the case of the lower producing Wyandottes, there were only 65 non-reactors or 11.1 per cent of the total, while there were 29 or 28.4 per cent of all the reactors. However, the effect of this difference in the proportion of reactors and non-reactors contributed by different breeds is not great, for, if the average egg production of the reactors and non-reactors of each breed is multiplied by the percentage representing the proportion of the total number (689) for that breed, the difference is still 53 eggs. For this reason and also because, as pointed out above, the average egg production of the reactors of each breed is significantly lower than that of the non-reactors, this factor will not be considered further.

It is interesting to note that the average egg production of the reactors appears to follow the egg production of the non-reactors of the same breed. Thus the egg production of the non-reacting Leghorns is higher than that of the non-reactors of other breeds, and the first year egg production of the Leghorn reactors is likewise higher than the average for the reactors

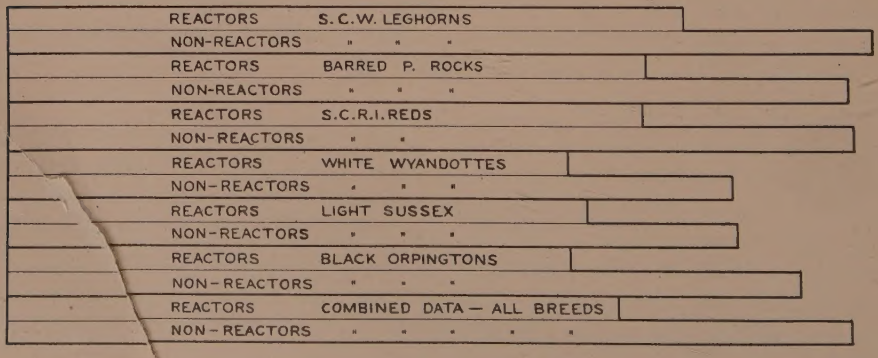

Figure 1. First year egg production of reactors compared with that of non-reactors.

of other breeds. This relation does not hold absolutely, but, as will be seen by examining table 1 and Figure 1, the relation is sufficiently marked to indicate that the reactors of a high producing strain might lay as well as the non-reactors of a low producing strain. It is, however, clearly brought out in table 1 and Figure 1 that the reactors lay considerably fewer eggs than similarly bred non-reactors of the same breed and variety.

TABLE 1. *Constants for first year (Nov. 1 to Oct. 31) egg production of pullets hatched in 1926 and 1927 that reacted negatively and positively (non-reactors and reactors) to the agglutination test for S. pullorum at the end of their first laying year.*

Breed	Number of Birds	Mean	Standard Deviation	Coefficient of Variation
Non-Reactors				
S.C.W. Leghorns	178	238.74 ± 2.07	41.03 ± 1.47	17.19 ± .63
Barred P. Rocks	151	221.17 ± 2.24	40.86 ± 1.59	18.47 ± .74
S.C.R.I. Reds	138	223.41 ± 2.46	42.84 ± 1.74	19.18 ± .81
W. Wyandottes	65	190.92 ± 4.30	51.38 ± 3.04	26.91 ± 1.70
Light Sussex	29	191.14 ± 4.96	39.57 ± 3.50	20.70 ± 1.91
Bl. Orpingtons	26	209.50 ± 5.43	41.03 ± 3.84	19.58 ± 1.90
All Breeds	587	221.68 ± 1.26	45.41 ± .89	20.49 ± .42
Reactors				
S.C.W. Leghorns	11	178.82 ±17.13	84.21 ±12.11	47.10 ± 8.14
Barred P. Rocks	27	168.11 ± 7.92	61.05 ± 5.60	36.31 ± 3.75
S.C.R.I. Reds	14	167.71 ±10.39	57.66 ± 7.35	34.38 ± 4.87
W. Wyandottes	29	148.72 ± 7.54	60.21 ± 5.33	40.48 ± 4.13
Light Sussex	8	153.25 ±10.54	44.21 ± 7.46	28.85 ± 5.25
Bl. Orpingtons	13	148.92 ±10.76	57.53 ± 7.61	38.63 ± 5.82
All Breeds	102	160.09 ± 4.19	62.71 ± 2.96	39.17 ± 2.11
Difference				
S.C.W. Leghorns		59.92 ±17.25	−43.18 ±12.20	−29.91 ± 8.16
Barred P. Rocks		53.06 ± 8.24	−20.19 ± 5.82	−17.84 ± 3.82
S.C.R.I. Reds		55.70 ±10.68	−14.82 ± 7.55	−15.20 ± 4.94
W. Wyandottes		42.20 ± 8.68	− 8.83 ± 6.14	−13.57 ± 4.47
Light Sussex		37.89 ±11.65	− 4.64 ± 7.24	− 8.15 ± 5.59
Bl. Orpingtons		60.58 ±12.05	−16.50 ± 8.52	−19.05 ± 6.13
All Breeds		61.59 ± 4.38	−17.30 ± 3.09	−18.68 ± 2.16

The actual and relative frequency of reactors and non-reactors in different fecundity classes is given in table 2. It will be seen that the distribution here is about what would be expected on the basis of the data presented in table 1. Thus, comparatively few of the non-reactors laid less than 150 eggs, or only 6.3 per cent, whereas 55.2 per cent laid 225 or more eggs. On the other hand, 35.3 per cent of the reactors, or over one third, laid less than 150 eggs, while only 14.7 per cent laid 225 or more eggs. These relations hold true reasonably well for the different breeds. Thus the percentage of non-reactors that laid 225 eggs or over is in every case greater than the percentage laying less than 150 eggs. In the case of the reactors, the percentage of birds laying less than 150 eggs is, for every breed except the Leghorns, greater than the percentage laying 225 eggs or more.

The same breed differences noted in connection with table 1 may be observed in the distribution of the reactors and non-reactors of the various breeds in table 2. Even with the small number of reactors (and in some cases, of non-reactors) of each breed, there is in each a marked decrease in the proportion of the higher producers among the reactors as compared with the non-reactors and an increase in the lower producers. This is undoubtedly the most important point brought out in this table. There are here also indications of breed differences.

TABLE 2. *Actual and relative frequency of reactors and non-reactors based on tests at the end of the first laying year in different fecundity classes (1926-27 and 1927-28).*

	NON-REACTORS						REACTORS					
	149 eggs or less		150-224 eggs		225 eggs or over		149 eggs or less		150-224 eggs		225 eggs or over	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
S.C.W. Leghorns	6	3.4	42	23.6	130	73.0	3	27.3	3	27.3	5	45.4
Barred P. Rocks	6	4.0	64	42.4	81	53.6	9	33.3	14	51.9	4	14.8
S.C.R.I. Reds	6	4.3	53	38.4	79	57.3	5	35.7	6	42.9	3	21.4
W. Wyandottes	12	18.5	36	55.4	17	26.1	11	37.9	16	55.2	2	6.9
Light Sussex	5	17.2	18	62.1	6	20.7	3	37.5	5	62.5	—	——
Bl. Orpingtons	2	7.7	13	50.0	11	42.3	5	38.5	7	53.8	1	7.7
Totals	37	6.3	226	38.5	324	55.2	36	35.3	51	50.0	15	14.7

The variability in first year egg production is shown in table 1. The actual variation, as indicated by the standard deviation, is greater in the case of the reactors than in the case of the non-reactors. When considered for the various breeds, the differences are not always statistically significant. The standard deviations are, however, consistently greater for the reactors. This, together with the difference in the standard deviation for the reactors and non-reactors of all breeds (17.30 ± 3.09), which is over five times as great as its probable error, indicates that the egg production of the reactors is more variable than that of the non-reactors.

The greater variability in the egg production of the reactors is also shown by the coefficients of variation. Here, again, the variability of the reactors is consistently greater than that of the non-reactors, although, as noted for the standard deviations, the differences are not always significant when compared with their probable error. The difference in coefficient of variation for reactors and non-reactors calculated from the combined data for all breeds is, however, statistically significant, being over eight times as great as its probable error, (18.68 ± 2.16).

Distribution of First Year Egg Production

The differences noted in the total first year egg production and in the variability of that production agree with the findings based on the data of the birds hatched in 1926. The first year egg production of the non-reactors

was again found to be significantly higher than that of the reactors. The distribution of the differences noted is shown in table 3 in which are set forth the constants for egg production by months during the first laying year.

An examination of the means in table 3 shows that the average egg production of the reactors was lower than that of the non-reactors in every month of the year. The actual differences ranged from three eggs in November, at the beginning of the year, to eight eggs in September, towards the end of the first laying year. It is of interest to note that the differences are statistically significant in every month of the year.

TABLE 3. *Constants for monthly (first year) egg production of all pullets of six breeds that reacted negatively and positively to the agglutination test for S. pullorum at the end of their first laying year.*

Month	Non-reactors (587 Birds)	Reactors (102 birds)	Difference	Diff. / E. diff.
		Mean		
Nov.	11.25 ± .26	8.12 ± .63	3.13 ± .68	4.6
Dec.	20.47 ± .20	16.13 ± .61	4.34 ± .64	6.8
Jan.	21.43 ± .17	18.14 ± .52	3.29 ± .55	6.0
Feb.	20.91 ± .14	17.30 ± .45	3.61 ± .50	7.6
March	22.75 ± .14	18.75 ± .50	4.00 ± .52	7.6
April	22.59 ± .13	17.99 ± .53	4.60 ± .55	8.4
May	21.99 ± .16	17.34 ± .56	4.65 ± .58	8.0
June	19.80 ± .16	13.75 ± .55	6.05 ± .57	10.6
July	19.18 ± .18	13.20 ± .58	5.98 ± .61	9.8
Aug.	17.28 ± .19	10.22 ± .55	7.06 ± .58	12.1
Sept.	14.78 ± .21	6.72 ± .50	8.06 ± .55	14.8
Oct.	8.95 ± .23	2.25 ± .31	6.70 ± .38	17.5
		Standard Deviation		
Nov.	9.39 ± .18	9.45 ± .45	−0.06 ± .48	0.1
Dec.	7.01 ± .14	9.18 ± .43	−2.17 ± .46	4.8
Jan.	6.12 ± .12	7.77 ± .37	−1.65 ± .39	4.3
Feb.	4.95 ± .10	6.81 ± .32	−1.86 ± .34	5.5
March	5.19 ± .10	7.55 ± .36	−2.36 ± .37	6.4
April	4.64 ± .09	7.92 ± .37	−3.28 ± .39	8.5
May	5.64 ± .11	8.43 ± .40	−2.79 ± .41	6.8
June	5.69 ± .11	8.22 ± .39	−2.53 ± .40	6.3
July	6.62 ± .13	8.73 ± .41	−2.11 ± .43	4.9
Aug.	6.69 ± .13	8.25 ± .39	−1.56 ± .41	3.8
Sept.	7.51 ± .15	7.55 ± .36	−0.04 ± .39	0.1
Oct.	8.27 ± .16	4.57 ± .22	+3.70 ± .27	13.7
		Coefficient of Variation		
Nov.	83.47 ± 2.54	116.37 ± 10.58	−32.90 ± 10.88	3.0
Dec.	34.22 ± .75	56.92 ± 3.45	−22.70 ± 3.53	6.4
Jan.	28.55 ± .61	42.85 ± 2.37	−14.30 ± 2.44	5.9
Feb.	23.68 ± .49	39.34 ± 2.13	−15.66 ± 2.18	7.2
March	22.82 ± .47	40.25 ± 2.19	−17.43 ± 2.24	7.8
April	20.55 ± .42	44.00 ± 2.45	−23.45 ± 2.48	9.4
May	25.65 ± .54	48.64 ± 2.79	−22.99 ± 2.84	8.1
June	28.74 ± .61	59.81 ± 3.70	−31.07 ± 3.75	8.3
July	34.52 ± .76	66.13 ± 4.28	−31.61 ± 4.34	7.3
Aug.	38.70 ± .87	80.73 ± 5.79	−42.03 ± 5.85	7.2
Sept.	50.78 ± 1.23	112.44 ± 9.97	−61.66 ± 10.05	6.1
Oct.	92.36 ± 2.99	202.72 ± 29.06	−110.36 ± 29.22	3.8

The distribution of the egg production of the reactors follows that of the non-reactors fairly closely. Thus the highest production is reached by both groups in March and the lowest production occurs in October. The egg

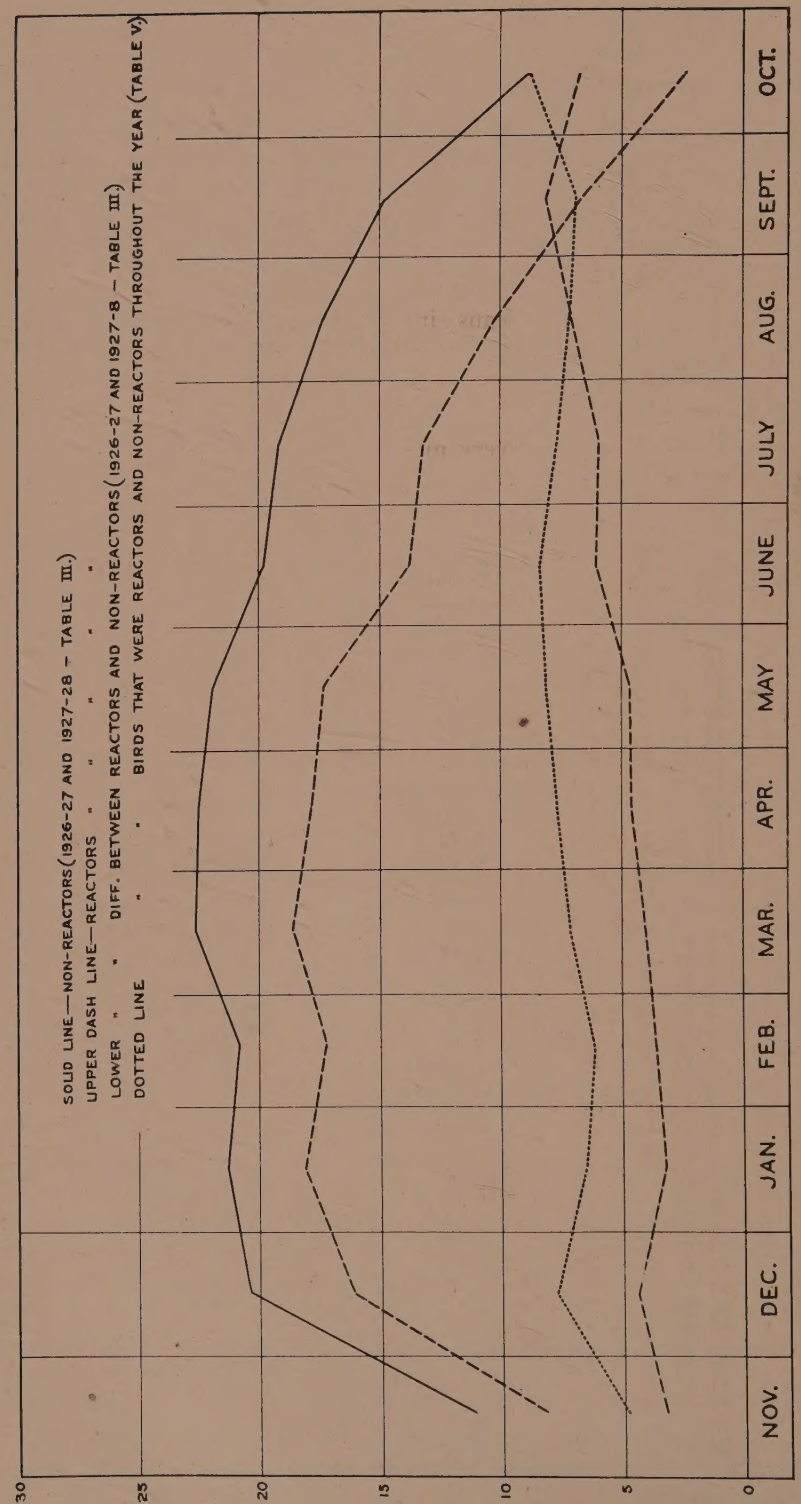

Figure 2. Monthly mean (first year) egg production of reactors and non-reactors and the differences between them.

production of the reactors decreased more rapidly than the egg production of the non-reactors after March, with the result that there is a gradual increase in the differences between the two groups. The greatest differences occur in June to October inclusive, while the differences are less and tend to fluctuate somewhat during the first seven months. These relations are brought out in Figure 2, which shows graphically the distribution of monthly egg production for the reactors and non-reactors and the differences between them given in table 3.

The standard deviations for the monthly egg production show a difference in every month between the reactors and the non-reactors. In this case the relations are not quite the same as those observed in the case of total first year egg production. Thus, in November, at the beginning of the year, the standard deviations are practically the same for both groups (9.39 and 9.45 eggs), but in December the standard deviation for the reactors remains about the same as for November, whereas that of the non-reactors decreases. The standard deviation for the reactors remains comparatively large, while that for the non-reactors followed approximately the distribution generally observed (*6, 7, 8, 9, 10, 11*) namely, a tendency to decrease with increasing egg production and to increase as egg production decreases. The standard deviations for the non-reactors are thus highest in the first three and the last four months, and lowest in the five months from February to June, inclusive. The standard deviation is fairly high in December and January, largely because some birds do not start to lay until late.

It will be noted (table 3) that the standard deviations for the reactors are significantly higher than those for the non-reactors from December to August, inclusive. In September they are again practically the same, while in October the standard deviation is greater for the non-reactors. This change in October is obviously due to the fact that nearly all the reactors had stopped laying, thus reducing variability in egg production to a minimum.

While the actual variability of the egg production of the reactors was less than that of the non-reactors in October, the relative variability as measured by the coefficient of variation was greater in the case of the reactors than in the case of the non-reactors not only in October but in every other month as well. The actual difference varies from 14.30 per cent in January to 110.36 per cent in October. These differences, when compared with their probable errors, are clearly significant in ten months (December to September, inclusive) and may be considered significant in the other two months. The coefficients of variation, therefore, lend support to the findings with regard to the variability in the total egg production of reactors as compared with that of non-reactors. Thus it was shown in table 1 that the total egg production of the reactors was actually and relatively more variable than that of the non-reactors. Table 3 shows that the egg production of the reactors as compared with the non-reactors was relatively more variable in every month of the year and actually more variable in nine out of the twelve months.

Egg Production of Birds that Did and Did Not React Throughout the First Laying Year

The birds hatched in 1927 were tested three times during their first laying year, as stated above. A certain number of these reacted positively

to the three tests, while others did not. There were 26 birds in the first group, while 282 never reacted to the test. It was considered likely that the figures for these two groups would throw some additional light on the differences in egg production of reactors as compared with non-reactors, and on some of the differences in variability that had been noted in the study based on the test made at the end of the first laying year. Accordingly, the data for these birds are presented herewith.

The figures for first year (November 1 to October 31) production are set forth in table 4. The difference shown in the mean egg production is even greater than that noted before, and amounts to 86 eggs. The standard deviation of the reactors is also greater than that of the non-reactors as in the case of the larger groups studied, and the difference here is again greater, or amounts to 28 eggs, as compared with 17 eggs (see table 1).

TABLE 4. *Constants for first year (Nov. 1 to Oct. 31) egg production of pullets hatched in 1927 that reacted negatively and positively to the agglutination test for S. pullorum throughout their first laying year.*

	Number of Birds	Mean	Standard Deviation	Coefficient of variation
Non-reactors	282	223.44 ± 1.78	44.28 ± 1.26	19.82 ± 0.58
Reactors	26	136.81 ± 9.61	72.65 ± 6.79	53.10 ± 6.21
Difference		86.63 ± 9.77	−28.37 ± 6.91	−33.28 ± 6.24
Diff./E. Diff.		8.9	4.1	5.3

The coefficients of variation also agree in a general way with those shown in table 1, but here again the coefficient of variation for the reactors is higher than that observed for the reactors shown in table 1. The coefficient of variation in this case is 53 per cent, whereas that obtained for the larger group is 39 per cent. The coefficient of variation for the non-reactors is practically the same as obtained for the corresponding group in table 1, with the result that the difference for this smaller group is greater. It would appear from the figures presented in this table that the variation in the egg production of this group of 26 birds, which reacted positively throughout their first laying year, is relatively greater than that of those which are only known to have reacted at the end of their first laying year.

The figures for monthly egg production are set forth in table 5. An examination of this table shows that the means follow in a general way those shown before. There appears to be here, however, a tendency for the egg production of the reactors to remain slightly lower throughout, and to decrease a little more abruptly towards the end of the first laying year. The column giving the differences in the egg production for the different months is also interesting. It shows that the differences are more consistent throughout than are those that were observed in table 3. Thus, except in November when the difference was 4.73 eggs, the differences ranged from 6.06 eggs in February to 8.96 eggs in October. There does not appear to be here the same tendency for the difference in monthly egg production to increase

towards the end of the year (see Figure 2), although the greater differences occur in the last six months. These differences are again significant for every month in the year.

TABLE 5. *Constants for monthly (first year) egg production of pullets of six breeds that reacted negatively and positively to the agglutination test for S. pullorum throughout their first laying year.*

Month	Non-reactors (282 birds)	Reactors (26 birds)	Difference	Diff. / E. diff.
		Mean		
Nov.	9.35 ± .36	4.62 ± 0.85	4.73 ± 0.92	5.2
Dec.	20.08 ± .30	12.38 ± 1.14	7.70 ± 1.18	6.5
Jan.	22.13 ± .25	15.58 ± 1.14	6.55 ± 1.16	5.6
Feb.	22.33 ± .19	16.27 ± 0.98	6.06 ± 0.99	6.1
March	22.91 ± .21	15.73 ± 1.14	7.18 ± 1.16	6.2
April	22.82 ± .17	15.12 ± 1.11	7.70 ± 1.12	6.9
May	22.34 ± .22	14.19 ± 1.24	8.15 ± 1.26	6.5
June	20.22 ± .22	11.88 ± 1.17	8.34 ± 1.20	7.0
July	19.39 ± .24	11.73 ± 1.25	7.66 ± 1.27	6.0
Aug.	17.28 ± .27	10.12 ± 1.17	7.16 ± 1.20	6.0
Sept.	14.51 ± .31	7.58 ± 1.09	6.93 ± 1.13	6.1
Oct.	9.84 ± .35	.88 ± 0.48	8.96 ± 0.60	15.0
		Standard Deviation		
Nov.	8.94 ± .25	6.40 ± .60	+2.54 ± .65	3.9
Dec.	7.45 ± .21	8.63 ± .80	−1.18 ± .83	1.4
Jan.	6.21 ± .17	8.60 ± .80	−2.39 ± .82	2.9
Feb.	4.61 ± .13	7.39 ± .69	−2.78 ± .70	3.9
March	5.27 ± .15	8.63 ± .81	−3.36 ± .82	4.1
April	4.29 ± .12	8.39 ± .78	−4.10 ± .79	5.2
May	5.52 ± .16	9.34 ± .87	−3.82 ± .89	4.3
June	5.49 ± .16	8.87 ± .83	−3.38 ± .84	4.0
July	6.09 ± .17	9.42 ± .88	−3.33 ± .90	3.7
Aug.	6.65 ± .19	8.84 ± .83	−2.19 ± .85	2.6
Sept.	7.64 ± .22	8.21 ± .77	−0.57 ± .80	.7
Oct.	8.76 ± .25	3.65 ± .34	+5.11 ± .42	12.1
		Coefficient of Variation		
Nov.	95.57 ± 4.56	138.61 ± 28.53	−43.05 ± 28.89	1.5
Dec.	37.11 ± 1.19	69.46 ± 9.11	−32.35 ± 9.18	3.5
Jan.	28.05 ± .86	55.17 ± 6.54	−27.12 ± 6.60	4.1
Feb.	20.66 ± .61	45.41 ± 5.05	−24.75 ± 5.08	4.9
March	22.99 ± .69	54.84 ± 6.49	−31.85 ± 6.53	4.9
April	18.80 ± .55	55.48 ± 6.60	−36.68 ± 6.62	5.5
May	24.72 ± .74	65.84 ± 8.41	−41.12 ± 8.45	4.9
June	27.14 ± .83	74.62 ± 10.15	−47.48 ± 10.18	4.7
July	31.41 ± .98	80.27 ± 11.36	−48.86 ± 11.40	4.3
Aug.	38.48 ± 1.24	87.37 ± 12.99	−48.89 ± 13.05	3.7
Sept.	52.60 ± 1.86	108.35 ± 18.54	−55.75 ± 18.64	3.0
Oct.	89.06 ± 4.07	412.79 ±228.66	−323.73 ±228.70	1.4

The standard deviations agree in general with what was observed in table 3, except that in this case the standard deviation is considerably higher for the non-reactors in November. The standard deviations are again greater for the reactors from December to September, inclusive, although the difference in September is very slight, agreeing in this particular with the figures given in table 3. The differences here range from 4.10 eggs in April to 0.57 eggs in September. On account of the small number of reactors, the probable

errors are rather high, with the result that the significance of the difference as noted for December, January and August appears doubtful. In view of the figures presented in table 3, however, it appears probable that there is an actual difference during these months. The standard deviation is again higher for the non-reactors than for the reactors in October, due to the fact that the former continued to lay later into the fall.

The coefficients of variation are again higher in every case for the reactors than for the non-reactors. The difference is consistent throughout, ranging from 24.75 per cent in April to 55.75 per cent in September, and rises to 323.73 per cent in October at the end of the year. On account of the small numbers involved, however, the figures do not always appear to be statistically significant when compared with their probable errors. Nevertheless, they do definitely support the figures previously presented to show that the variability in the production of the reactors is very much greater than that of the non-reactors.

It is of interest to note in connection with variation in egg production that the individual egg records varied widely. The range in egg production previously noted (*1*) was from 9 to 283 in the case of the reactors and from 4 to 305 eggs in the case of the non-reactors. In 1927-28 the lowest record made by a reactor was 3 eggs and the highest was 248 eggs. Both records were made by birds that reacted positively to all three tests. The corresponding records for non-reactors ranged from 1 to 310 eggs. Obviously, low egg production may be due to other causes than infection with *S. pullorum*. Although it cannot be asserted on the basis of our data that reactors will not make as high individual records as non-reactors, it is, nevertheless, of interest to note that the highest record made by the latter is 62 eggs above the corresponding record for the reactors. In spite of this difference, a number of the reactors would ordinarily have been retained for breeding on the basis of the egg records made. This supports our previous finding that it is not possible to eliminate reactors by culling on the basis of egg records.

The distribution of the egg production of the non-reactors shown in tables 3 and 5 does not differ significantly. On the other hand, the group of 26 birds that reacted throughout the year (table 5) laid at a consistently low rate throughout the year. Their average egg production was lower in nearly every month than the egg production of the larger group classified on the basis of a test at the end of the year. The difference is particularly marked during the first nine months and is shown indirectly in Figure 2. It seems probable that the distribution of egg production of any group of birds classified as reactors on the basis of a test at the end of the year will be influenced by the proportion of birds that became infected during their first laying year. Such birds would be expected to lay at a good rate until some time after they became infected, thus raising the average egg production of the group, particularly during the first part of the year. This probably accounts, at least in part, for the differences in the distributions of egg production for the reactors as given in tables 3 and 5.

Summary

Data are presented on the first year (November 1 to October 31) egg production of 689 hens of six breeds hatched in 1926 and 1927. On the

basis of tests at the end of the laying year, 102 birds reacted negatively and 587 reacted positively to the agglutination test for pullorum disease.

The average first year egg production of the reactors was 61.59 ± 4.38 eggs lower than that of the non-reactors, or 160 eggs for the former as compared with an average of 221 eggs for the latter (table 1). There was also more variation in the first year egg production of the reactors than of the non-reactors as shown by the standard deviation and the coefficient of variation.

Only 6.3 per cent of the non-reactors laid less than 150 eggs, as compared with 35.3 per cent of the reactors. On the other hand, 55.2 per cent of the non-reactors laid 225 or more eggs, while 14.7 per cent of the reactors made such records (table 2). The differences noted in first year egg production of reactors and non-reactors were consistent for the six breeds, although the exact figures varied.

The egg production of the reactors was significantly lower than that of the non-reactors in every one of the twelve months. The actual difference varied from 3 eggs in November to 8 eggs in September (table 3 and Figure 2). The egg production of the reactors was more variable as measured by the standard deviation except in October, when variability was reduced by the low egg production of the comparatively few reactors that were still laying. The coefficient of correlation shows that the egg production of the reactors is relatively more variable in every month than that of the non-reactors.

The birds hatched in 1927 were tested three times, at the beginning, the middle and the end of the first laying year. Twenty-six birds reacted to all three tests, while 282 never reacted. A comparison of the egg production of these two groups gives results similar to those obtained when the birds are classified on the basis of a single test at the end of the year. The possible significance of apparent differences is discussed.

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THE DOWNY MILDEW OF THE HOP IN BRITISH COLUMBIA

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Introduction

The downy mildew of the hop, *Pseudoperonospora Humuli* (Miy. & Tak.) Wils., was first observed in British Columbia in the spring of 1928. During that year the disease was found in epidemic proportions in all the commercial hop yards of Sardis, Sumas and Agassiz. Not only was it found in all the commercial yards but also on escaped hops many miles from the commercial yards. Some attempt was made by the growers to control the disease in 1928 but it was apparently too well established before the removal of the diseased "spikes" and spraying with Bordeaux commenced. Losses were estimated as high as fifty per cent by many growers through infection of the bines and cones.

The Disease Symptoms

The disease symptoms in British Columbia appear to agree with those described by Salmon and Ware (*1, 2*). These authors (*3*) came to the conclusion that the downy mildew of the hop in British Columbia is the same as the European form, and we have found no evidence to the contrary.

The most conspicuous feature of the disease are the pale green, spike-like, abnormal growths. In 1929 we found that these spike-like growths fell into two more or less distinct types both of which occurred throughout the season. The first type occurred chiefly as "basal spikes". They were first found in April among the normal young green bines that developed from the crown. Compared with the normal shoots these "basal spikes" were much reduced in size. The leaves were light green to silvery grey in colour, small and curled downwards. The stem was brittle and slightly brown within. These "spikes" rarely attained a length of more than a foot before they began to die. Infection seemed to proceed from the base upwards for the lower leaves were the first to die. Similarly, the lower leaves were the first and the leaves of the tip the last to produce conidiophores and conidia. The fruiting bodies were evenly distributed over the entire lower surface of the leaves on this type of "spike". Later in the season, as lateral and terminal growths, similar "spikes" were found but the "lateral" and "terminal spikes" were usually distinct in character. They were more normal in appearance than the typical "basal spikes". The leaves were greener, less reduced in size and seldom curled. The stems were brittle and slightly brown within, but unlike the typical "basal spike" infection, seemed to proceed from the tip downwards. The conidiophores and conidia appeared first on the upper part of stem and leaves. Also the fruiting surface was more restricted, being confined, for the most part, to the zone bordering the veins.

The typical symptoms of the disease on the ordinary leaves are the angular leaf spots. Before sporulation occurs these spots appear as water soaked areas which stand out clearly, only when the leaf is held between the observer

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and the light. After sporulation occurs this tissue turns brown and dies. At this stage the spots are quite conspicuous to the casual observer. These spots do not seem to increase in size after the conidiophores are produced, but the merging of individual spots may form a large dead area. Little leaf infection occurred in 1929 in any of the commercial yards due partly to the control measures and partly to the dry warm weather.

Likewise little cone infection occurred in 1929, but that which was found exhibited the characteristic symptoms as described by Professor Salmon and his associates. When infection occurred in the "burr" stage, a hard, brown, stunted cone was produced. When infection occurred in the early cone stage the bracteoles and bracts were attacked, the former more severely. These ultimately turned brown. When infected at a still later stage, the relative immunity of the bracts was still more pronounced. Conidiophores and conidia were borne on both surfaces of the bracteole, but on the lower surface only of the bract. It is noteworthy that the resin glands are on the surface of the bract which does not produce conidia.

The Mode of Infection

When the disease first appeared in 1929 we found that the "basal spikes" were more abundant where the crowns were surrounded by grass. This is suggestive that the disease is carried over the winter as oospores. If hybernating mycelia in the crown had been the principal wintering agency, we can see no reason why grass around the crowns should promote the development of "basal spikes". On the other hand, it is quite probable that grass would make conditions more favourable for the germination of the oospores. Other indirect evidence was obtained to support the view that the disease does not normally winter as hybernating mycelia in the crown. Plants were marked that were very severely infected in the fall of 1928. Before growth commenced in the spring of 1929 the crowns of these plants were dug up, and their surfaces were sterilized with mercuric chloride. They were then planted in a greenhouse, but no "spikes" or other symptoms of the mildew developed upon them.

The modes of infection probably differ and lead to the development of two distinct types of spikes above described. It seems probable that the typical "basal spikes" develop from the original crown infection, even when they appear on plants some distance from the ground. The progress of the disease from the base to the tip supports this statement. On the other hand, it seems probable that the typical lateral or terminal spike is produced by zoospore infection at the growing point of a young shoot. This is supported by the observed tendency of the disease to progress from the tip to the base in this type of "spike" and the fact that we were able to produce this type of inoculating a young shoot at the growing point with a suspension of zoospores.

The germination of the conidia commenced at once when they were suspended in water at a favourable temperature. The period of germination varied from one and a half hours at 63° F. to several hours at higher and lower temperatures. On germination the protoplasm first became granular and then emerged as a mass through a small opening at the tip. The mass then broke into several zoospores. Eight zoospores were the maximum number observed by us. Occasionally, the protoplasmic mass broke apart

before emergence was complete. When such occurred, the zoospores trapped within appeared to be unable to escape.

Artificial Infection Experiments

In order to study the factors influencing zoospore infection of the leaves we found it more convenient to use excised leaves. These were placed in petri dishes containing small amounts of water, and inoculated by painting the surfaces with suspensions of zoospores. The leaves inoculated in this manner produced conidiophores and conidia in about the same time as in the open. During July and August the average incubation period was about 6 days, but it varied from 2½ to 10 days.

The young leaves were more susceptible than the old both in the field and in petri dishes as judged by the relative production of summer spores per unit of surface. Only in a few cases did the old leaves of susceptible hop varieties fail to become infected.

No positive evidence was obtained that uninjured leaves could be infected through the upper surface. When the upper surface was injured by scratching with a needle, infection took place when the inoculum was painted on the upper leaf surface only.

By painting the growing points of young shoots, "spikes" developed of the characteristic "lateral" or "terminal type". The stem became brittle and exhibited the characteristic brown discoloration within.

Resistance of Species and Varieties

The common nettle of British Columbia, *Urtica Lyallii* S. Wats. is apparently completely resistant to the hop mildew. No evidence of infection was obtained by inoculating the normal or excised leaves with zoospore suspensions. Although large numbers of nettle plants were examined no infection by any species of downy mildew was discovered.

Of the four commercial varieties of hop grown in British Columbia, Early and Late Clusters were very susceptible, Kent Goldings was somewhat resistant and Fuggles was immune. Some of the wild hop varieties were more susceptible than any of the cultivated varieties. On the other hand wild hops were found that appeared to be immune.

Control Measures

Our own experience, and that of the European investigators, shows that the spread of downy mildew of the hop is favoured by damp and relatively cool weather. Since the normal summer season in the hop districts of British Columbia is relatively dry and warm, there is little doubt that the disease may be controlled here with greater certainty than in the majority of the European hop districts.

Based upon our observation that basal spikes are more abundant on crowns surrounded by grass, care should be taken to keep the hopyards free from grass.

It is self-evident that the complete removal and destruction of the plant residues is an important control measure, due to the evidence that oospores are responsible for the wintering of the disease.

The detection and removal of the "spikes" is undoubtedly an important control measure. Since the weather conditions early in the season

are favourable to the growth of the fungus this work should begin as soon as the hops begin to grow. The removal of spikes is a control measure that should be continued throughout the season, for our evidence suggests that in British Columbia throughout the season they are the principal source of inoculum.

In one hopyard the crowns were dusted with a 1-8 mixture of anhydrous copper sulphate and hydrated lime shortly after growth commenced. This practice did not appear to reduce the number of "basal spikes".

In 1929 spraying with 4-4-40 Bordeaux (1 per cent) was started when the bines were not more than six feet high.

The European growers start to spray somewhat later. They claim that an early application of Bordeaux is likely to injure the growing points of the young bines. In British Columbia, no significant injury occurred, hence, it is probable that the early spray will always remain an important control measure, owing to the favourable conditions for the development of the fungus that normally prevails at the time.

In most of the yards, spraying or dusting was continued at about 10 day intervals until shortly before the hop plants reached the "burr" stage. Since all the commercial yards were either sprayed or dusted no comparative evidence was obtained as to the value of these control measures. Little leaf infection occurred in any of the yards. Our only check was a small hop nursery where no spraying was done. In this nursery the "spikes" were removed at frequent intervals and practically no leaf infection developed. This leads us to believe that the spraying operations were of doubtful value this year. During July and August of any year, it is doubtful whether it is an advantage to spray owing to the comparatively dry warm weather. The likelihood of cool damp weather in the fall suggests that an application of spray just before or after the "burr" stage is a wise precaution.

In spraying with Bordeaux considerable difficulty was experienced with all types of spray machinery in securing a satisfactory spread on the under surface of the hop leaves. Even when the spray nozzles were directed by hand upwards through the foliage the coverage was not perfect on the under surface of the leaves. Since the principal channel of leaf infection is through the under surface of the leaves, we attempted to improve the coverage by the addition of spreaders to the Bordeaux. The spreaders tested included skim-milk, calcium caseinate, glue, whale oil soap, sodium resin soap and potassium resin soap. The best spreads were obtained by the addition of whale oil soap and potassium resin soap. The former, however, produces an objectionable curd which is inclined to cause trouble through the clogging of the nozzles. Potassium resin soap proved to be the most satisfactory. It was prepared by dissolving together one part potassium hydroxide, two parts resin and three parts water, and two quarts were added to every 100 gallons of Bordeaux. The sodium resin soap had little value as a spreader although it was prepared in the same way except that sodium hydroxide took the place of potassium hydroxide.

When the Bordeaux spray was applied shortly after the bines had been sprayed with an oil emulsion for aphid control, an excellent spread of the Bordeaux occurred without the addition of a spreader.

In one yard dust was used exclusively instead of liquid Bordeaux. The dust consisted of a 1-8 mixture of powdered anhydrous copper sulphate and hydrated lime. Although this yard was more free from the disease than any other, there was not sufficient leaf infection in any of the yards to base any conclusions upon the relative merits of dust and liquid Bordeaux. An examination of the hop plants showed that a satisfactory coverage was only secured when the dust was applied while the plants were covered with dew. Without taking into consideration the presence of dew, the application of the dust at night was no insurance of a satisfactory coverage. Furthermore, a type of duster was preferable in which the dust was directed against the foliage. It appeared as if the dust had to strike the foliage with a definite velocity to ensure permanent contact.

Summary

1. The downy mildew of the hop was first reported in British Columbia in 1928 and it occurred that year in epidemic proportions in all the commercial hop yards.
2. The disease symptoms found in 1929 were not unlike those reported by the European investigators. Two types of "spikes" occurred that were more or less distinct. Leaf and cone infection was comparatively rare.
3. Hybernating mycelia in the crown did not appear to be the principal cause of the reappearance of the fungi, for grass around the crowns appeared to favour the development of "spikes"; and crowns developed no disease symptoms if surface sterilized before replanting.
4. Zoospore infection at the growing point may be responsible for the development of typical "lateral" and "terminal spikes".
5. The artificial infection experiments showed that: young leaves were more susceptible than old; uninjured leaves were infected through the lower and injured leaves through both surfaces; the common nettle was immune and all the commercial varieties of hops were susceptible except Fuggles.
6. Among the control measures applied, it appeared advantageous to add potassium resin soap to the Bordeaux, and to use dust only when it could be directed against damp foliage with considerable force.

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A TEST OF THE EFFECT OF ENVIRONMENT ON GENETICALLY SIMILAR MARQUIS WHEAT.

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It has been thought, in connection with the regulations of the Canadian Seed Growers' Association respecting the purity and uniformity of Elite Stocks, that fluctuations in type due to environmental influences were so large as to necessitate a wide range of allowable variation in a highly pure breeding strain of wheat. Newman (*4*) investigated the effect of environment on glume characters in several varieties of spring wheat grown at different places in Canada. He drew attention to the "rather remarkable uniformity in the general shape of shoulder as well as in the shape and length of beak" in the variety Marquis (strain 0.15 was used). He found similar uniformity of glume character in the varieties Kitchener, Garnet and Early Red Fife. DeLong (*1*) recently reported the results of an investigation of variation in Marquis where the plants were spaced different distances apart. He found that under very extreme conditions there was a fairly wide range for various plant and spike characters.

Owing to the importance of the problem a test was made by the writer in 1928 to furnish further information.

Materials and Methods

Briefly the details of the test were as follows. Twenty-five closely similar spikes of Marquis, Sask. 70 were chosen from an increase field. One seed from each of these spikes, 25 seeds in all, was sent to each of nine prominent farmers of the Prairie Provinces. Each man then had twenty-five seeds genetically identical with those of each of the others, barring of course, possible effects of incomplete homozygosity, natural crossing and mutation. The co-operators were directed to sow the twenty-five seeds two inches apart in a row between two other rows of wheat on summer-fallow, and, when they ripened, to wrap carefully the twenty-five plants and send them to the author for examination. Each co-operator was asked to fill in a questionnaire respecting the conditions governing the growth of his set of plants.

When the plants were received at Saskatoon an individual plant record was made of plant height, number of stools, spike type and seven glume characters. Glume characters have long been recognized as highly important and reliable in wheat variety classification and description. The necessity of taking glume characters on strictly comparable material was emphasized by the writer (*2*) in a recent study of strains of Marquis wheat. In that study it was found that one or two secondary glumes located about one-third of the distance from the bottom to the tip of a representative spike furnished reliable material for the determination of glume characters. The methods described for taking glume character data in that study were used in the present study.

Results

Plants and answers to a questionnaire were received from six of the coöperators. Two farmers were unable to complete the test and the material

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TABLE 1. *The results obtained from a test of genetically similar Marquis wheat grown in six localities of Western Canada in* 1928.

District:	Rosthern.	Wild Rose	Lashburn	Fenn.	Solsgirth.	Saltcoats
Location:	N. Central Saskatchewan	N. Central Saskatchewan	N. Western Saskatchewan	Central Alberta	Central Manitoba	Eastern Saskatchewan
Soil:	Clay Loam.	Black loam.	Chocolate clay loam.	Good loam.	Heavy black loam.	Sandy loam.
Season:						
May	Dry, hot	Dry, hot	Dry, hot	Dry, hot	Dry, hot	Dry, hot
June	Mod. dry	Dry	Ideal	Wet, cool	Wet, cool	Wet, cool
July	Dry, hot	Dry, hot	Dry, hot	Dry, hot	Wet, warm	Wet, warm
August	Mod. wet hot to cool	Wet, cool	Mod. wet hot to cool	Wet, cool	Mod. wet hot to cool	Mod. wet hot to cool
Surrounding crop:	Reward	Marquis	Marquis	Marquis	Garnet	Garnet
Distance from surrounding crop	12″	6″	6″	7″	16″	6″
Date sown:	May 7	May 15	May 12	May 2	Apr. 24	May 10
Date ripe:	?	Sept. 5	Aug. 26	Sept. 5	Aug. 20	?
Weeds present:	None	3 small ones	2 small ones	None	None	None
Number of plants harvested:	23	25	24	25	24	21
Min. height in cms.	125	68	103	107	124	109
Max. height	148	98	115	130	147	130
Av. height	139	91	110	118	138	119
Min. number of stools	4	1	2	1	1	2
Max. stools	11	3	4	13	7	5
Av. stools	7.6	1.4	3.0	6.5	4.5	2.9
Spike type	Typical*	Typical*	Typical	Typical	Typical*	Typical*
Min. spike length in mm.	86	66	76	69	73	64
Max. spike length in mm.	120	87	95	104	112	103
Av. spike length	98	75	83	88	86	77
Awn length	Typical	Typical	Typical	Above average	Typical	Typical
Glume length	Average	Sl. short	Average	Sl. long	Average	Average
Glume width	Average	Average	Average	Sl. narrow	Sl wide	Average
Shoulder shape	Nearly sq.	Square	Nearly sq.	Sl. raised	Nearly sq.	Nearly sq.
Shoulder width	Average	Average	Average	Sl. narrow	Average	Average
Beak shape	Acute	Acute	Acute	V. acute	Acute	Acute
Beak length	Average	Long	Average	Long	Average	Average
Beak width	Average	Average	Sl. wide	Average	Average	Average

* One plant was distinctly off-type and was probably due to natural crossing at Saskatoon in 1927.

Abbreviations: Sl.—slightly. V.—very. Min.—minimum. Max.—maximum. Av.—average, Mod.—moderately, Sq.—square.

sent in by another was badly damaged and unaccompanied by definite information. The results are given in table 1. The soil and growing conditions varied considerably among the six localities. The driest season and latest sowing occurred at Wild Rose. It will be observed in table 1 that the Wild Rose plants were much shorter than any of the others, stooled less and had shorter spikes. At Lashburn, where the season was somewhat like that at Wild Rose, although not as dry, the plants were taller and the spikes longer but not as tall or as long as in the remaining four districts. Conditions for growth were exceptionally good at Rosthern, Fenn and Solsgirth. The plants in these districts stooled well and had moderately long spikes. It is interesting, however, that the Fenn plants were distinctly shorter than those from Rosthern and Solsgirth and very similar to those from Saltcoats, although the latter stooled much less and had relatively short spikes.

The most important results are those concerned with spike and glume characters for it is chiefly by these characters that the uniformity and purity of a variety are judged. The spike type throughout each lot of plants was typical Marquis† although the growing conditions for the various lots were different and the variation in spike length was high at Fenn, Solsgirth and Saltcoats.

A cursory examination of the material revealed slight but distinct differences in glume characters between some of the strains. Data on seven glume characters are shown in table 1. It was found that two groups of plants, those grown at Rosthern and Saltcoats, were almost identical in glume characters. The Lashburn group differed from these in having a slightly broader beak but in other respects was not different. The Solsgirth plants definitely tended toward slightly broader glumes than those of the other five groups but in other respects closely resembled the Rosthern and Saltcoats lots. The remaining two groups differed markedly although slightly from the others, the Wild Rose lot having shorter glumes, squarer shoulders and longer beaks, and the Fenn group being distinguished by longer glumes, longer beaks and shoulders that were slightly elevated above the square condition. The drawings in Figure 1 give a composite picture of the glume characters shown by the plants grown in each locality.

The differences between groups of plants grown in the various localities were small and yet some of them were sufficiently noticeable and consistent to make it possible to guess the district from the appearance of a single glume. For example, a spike taken from the Fenn group of plants could generally be picked out if mixed with spikes from the Rosthern, Lashburn or Saltcoats lots. Similarly, a spike of the Wild Rose lot could usually be detected in the Rosthern, Lashburn or Saltcoats lots and probably in the Solsgirth lot but not easily in the Fenn group. Spikes from the Solsgirth group were detectable in either the Fenn or Wild Rose lots but not in the others. If all of the lots of spikes were mixed together and the spikes looked over one by one, the observer would probably decide that the material was all Marquis but not especially uniform in glume characters. None of the plants was sufficiently different from the rest to be considered off-type or even questionable Marquis.

†Excepting four off-types that appeared to be the result of natural crossing and need not be considered here.

In Figure 2 glumes from all of the plants received from two localities, Fenn and Rosthern are shown. Even to the inexperienced eye the general differences and resemblances are apparent. Three interesting features are shown by this photograph, (1) the distinct yet small differences between the two groups of glumes, (2) the appreciable variation within the Fenn group for shoulder shape and beak length contrasted with the greater uniformity of the Rosthern glumes and (3) the very strong resemblance between the two glumes of the same plant in nearly all cases.

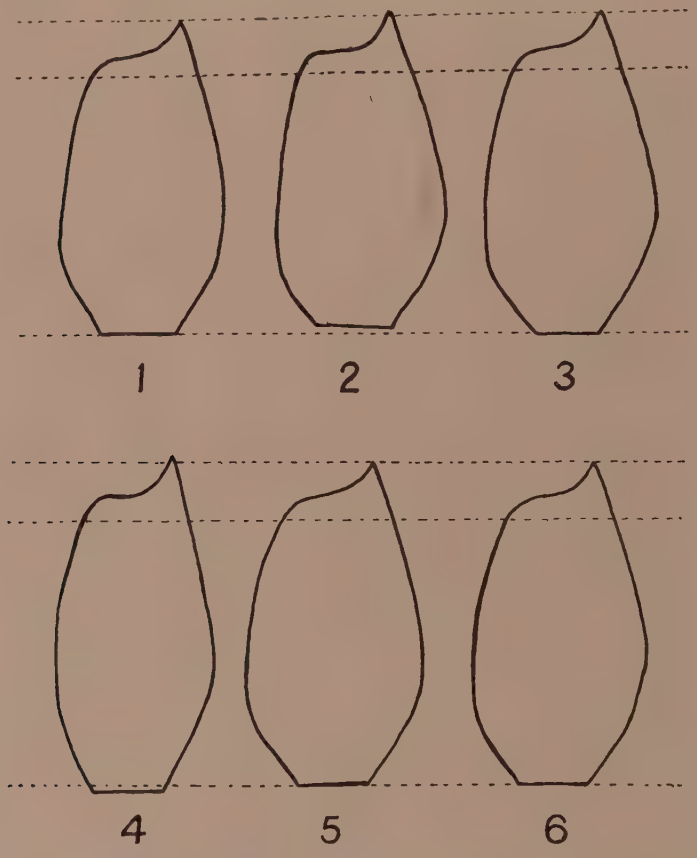

Figure 1. Representative shapes of the secondary glume of 25 genetically similar Marquis plants grown in six different localities in Western Canada in 1928 as follows: 1—Rosthern, Saskatchewan; 2—Wild Rose, Saskatchewan; 3—Lashburn, Saskatchewan; 4—Fenn, Alberta; 5—Solsgirth, Manitoba; 6—Saltcoats, Saskatchewan. The dotted lines draw attention to the glume differences, particularly to glume length, shoulder shape and beak length. These lines are all parallel and those in the top row of glumes are the same distances apart as those in the lower row.

Discussion

The investigation herein reported was fairly limited in extent and yet sufficiently comprehensive in its scope and sufficiently clearcut in its results to warrant definite conclusions. Genetically similar material, when grown under different climatic and soil conditions, was found to vary considerably in certain characters and very little in others. The characters which showed

large response to environmental conditions were earliness of maturity, plant height, tillering and spike length. These characters are well known to be influenced markedly by environment.

Spike type was somewhat variable but only within the limits allowable in the variety Marquis. This character is really a composite one consisting of several others, viz: the shape of the tip, the length-width ratio, the fertility of the basal spikelets, the dorso-ventral shape and the lateral shape. For the present study it was considered sufficient to use the more general designation, spike type.

Figure 2. The secondary glumes of all of the plants grown in two localities in 1928. A and B are the glumes from the plants grown in Rosthern, Saskatchewan; C and D are the glumes from the plants grown at Fenn, Alberta. Two secondary glumes from about one-third the distance from the bottom to the top of a representative spike are shown for each plant. For example, in double row A the first two glumes, one above the other, are from the same plant. In a few plants several glumes were missing or damaged and only one suitable glume remained.

The seven glume characters showed very little variation between one group of plants and another. There was almost complete similarity in glume characters between plants grown at Rosthern, Lashburn, Saltcoats and Solsgirth, places hundreds of miles apart, on soils varying from a heavy black loam to a sandy loam. The plants grown at Fenn and Wild Rose differed

from the other groups slightly though distinctly, but these differences were not large enough to cause any plant to be considered off-type even when fully developed spikes of all the plants from the six localities were mixed before being examined.

As a test of the practical importance of the environmental effects, a group of twenty inspectors of the Dominion Seed Branch examined representative spikes from the different groups of plants without knowing the identity of the material. They also looked over spikes from all of the plants grown in several of the localities. In no case did they consider any plant to be off-type.

In most fields of Marquis off-type plants occur. It was shown by the writer (*3*) in a recent study of several hundred progeny tests from seed drill and elevator samples that natural crossing was probably responsible for nearly all of the impurities that were not identifiable as named varieties. But usually a small percentage of moderately off-type plants are found that cause one to wonder whether they are due to natural crossing and related genetical causes or solely to the effect of the environment. The present study shows that, for the season of 1928 and the material used, environmental effects were not important as far as critical spike and glume characters were concerned. The material was grown in most cases under as near normal field conditions as it was possible to attain and still retain the identity of the individual plants. Furthermore the range of soil and climatic conditions covering the test was large. It seems reasonable, then, to assume that the results of this study are applicable to the average field of high quality Marquis, and probably to fields of other varieties of wheat as well.

Stated in another way, it is hardly likely that more variation in spike and glume character occurs among the *normal* plants within a single field of genetically similar Marquis than was found in the present study between plants grown in districts distributed through three provinces. One would not expect, then, in such a field, to find off-type plants which owe their off-typeness to the effect of environment. This statement, of course, applies only to plants which have had an average opportunity to grow, being neither excessively crowded nor standing alone. It is assumed also that the plants used for the determination of spike and glume characters are normally developed, of average size and in no case noticeably diseased or otherwise injured.

Summary

A study was made of morphological characters in gentically similar Marquis plants grown in six localities of Western Canada in 1928. It was concluded from the results that the effects of environment were not important as far as critical spike and glume characters were concerned in the material studied.

Acknowledgements

The writer wishes to express his appreciation of the generous co-operation of those who made the test possible. The six farmers who completed the test were: Mr. G. S. Canfield, Wild Rose, Saskatchewan; Mr. R. D. Kirkham, Saltcoats, Saskatchewan; Mr. M. P. Mountain, Solsgirth, Manitoba; Mr. F. W. Townley-Smith, Lashburn, Saskatchewan; Mr. H. G. L. Strange, Fenn, Alberta; Dr. Seager Wheeler, Rosthern, Saskatchewan.

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A CASE OF METALLIC DISCOLORATION OF CHEDDAR CHEESE

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Introduction

It has been shown by previous investigations that certain types of discoloration in cheese may be attributed to the action of metals or their salts. Leitch (*1*) in 1927 reported an investigation of what he termed black spot in cheese which was found in Scots and English Cheddars both white and coloured. It was also found in Dunlop and Cheshire cheese and had been reported in American and New Zealand Cheddars. According to his description, the discoloration varies in size from pin points to the size of a shilling, and is circular in shape, or more rarely is found in the form of veins. Experimental work showed that the discoloration was not of bacterial or enzymic origin but was due to lead contamination. Orla-Jensen (*2*) states that the commonest colour defect is the turning gray or blue of the curd, due to admixture of salts of iron or copper. Iron may come from the water, rusty pails, or, if the milk is heated by direct steam, from the steam pipes. Copper may come from the cheese vat or, in the case of Parmesan cheese, from the untinned copper vessels in which the evening milk is often kept for eighteen hours. In the case of iron, the colour is due to ferrous salts, for which reason the outer portion of the cheese will not be coloured, while the colour disappears from a slice of the cheese which is exposed to the air. In the case of copper, the conditions are reversed; as the colour is due to the green cupric salt, the outer portion will be the most affected, and a slice cut out of the cheese will only develop the full colour after exposure to air for some time. Metallic sulphides, stable in air, will be produced where hydrogen sulphide is formed.

The present paper describes a type of metallic discoloration in white Cheddar cheese differing in description from cases previously reported.

Report of Complaint

On August 20, 1929, a colour complaint on cheese was reported to the Federal Dairy Commissioner through the Agricultural Products Representative for Canada in London, England. The vat of cheese affected arrived in London on June 20, 1929. Records show that it was manufactured in an Eastern Ontario factory and that at the time of grading for export on June 4, 1929, it was of first quality in colour and flavour.

While the amount of cheese affected with the metallic discoloration was very small and the conditions of manufacture unusual, it has, nevertheless, been considered of sufficient importance to the industry to be placed on record.

Description of the Colour Defect

In order to ascertain the cause of the colour defect, a 20 pound sample was submitted to the Division of Dairy Research for laboratory study. It was received on September 5, 1929. On examination it showed the following

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characteristics. On cutting new surfaces, numerous discoloured areas were visible. These areas varied in size from that of a pin head to about one-half inch in diameter. In shape these areas were irregular. In colour they varied from a light brown to yellowish brown and in some instances presented the appearance of early stages of iron rust. The affected areas shaded from the yellowish brown in the centre to a lighter shade at the outside. Closer examination with the naked eye showed that many of the discoloured areas contained a black hard core, while the interior of others were smudgy black in colour. Figure 1 shows a photographic section of the discoloured cheese.

Figure 1. A section of Cheddar cheese showing discoloured areas surrounding the embedded "steel wool" particles.

Bacteriological

In order to determine if the discoloration was due to the growth of microörganisms, a number of the discoloured areas were removed with a sterile knife, ground in sand, diluted and plated. The following dehydrated media were used; agar, gelatin, whey, potato and wort. A study of these plates after 6 days incubation at 25°C. gave no clue as to the cause of the defect.

Chemical

Since nothing abnormal could be detected in the discoloured cheese by bacteriological methods, ordinary qualitative chemical tests were applied to the discoloured areas in question. In all of the areas examined, positive tests were found for the ferrous salt of iron. Microscopic examination of a number of these areas showed the presence of a smudgy black colour. A thorough microscopic examination revealed small fragments of steel wire in many of the discoloured areas. A number of pieces of steel wire varying from a fraction to one-half inch in length were also found. Figure 2 shows some of the larger pieces of steel wire partly imbedded in sections of the discoloured cheese.

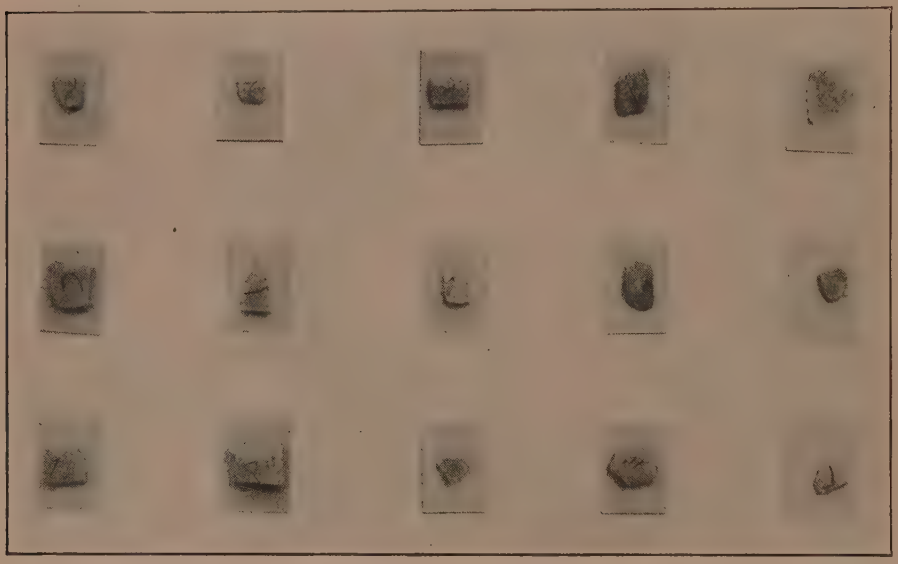

Figure 2. Sections of Cheddar cheese showing partly embedded pieces of "steel wool".

Source of Steel Wire

On inquiry of the cheesemaker, it was admitted that "steel wool" was used in cleaning the vats. The explanation probably is that as the pieces broke off, they settled to the bottom of the vat and were picked up by the particles of curd on the next day's make.

Recommendations

In view of the above experience, the use of "steel wool" for scouring and cleaning vats should not be practised, as small particles and pieces may find their way into the curd through improper flushing of the vat, resulting in a similar colour defect to that just described.

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COD LIVER OIL FOR GROWING PIGS

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Since the discovery of the vitamines, and the fact that cod liver oil is one of the richest sources of certain of them, numerous experiments have been carried out to ascertain just what place this product should be accorded in practical feeding operations.

To date the evidence is somewhat contradictory, though most investigators now agree that the general feeding of cod liver oil to cattle, horses or sheep, is without beneficial effect.

Poultrymen on the other hand place considerable dependence on this product as a preventive of certain diseases related to a vitamin deficient diet.

Between these two extremes stand the hog raisers, trials having in some cases shown beneficial results following cod liver oil feeding, while in others, the use of this product appears to be of questionable value.

Evvard (*1*) reports noticeably faster gains and more economical feed consumption by pigs on a ration of cod liver oil, tankage, shelled corn (mixed, mostly yellow) and minerals as compared to a similar ration, less the cod liver oil.

Rice, Mitchell and Laible (*2*) found that the addition of cod liver oil (about ¾ ounces per pig daily) to a ration of white corn and tankage, gave striking results after the first six weeks of feeding, as compared to a second group receiving the same feed combination but no cod liver oil. These results, however, are attributed by the authors to the vitamin A rather than to any vitamin D supplied in the oil.

Patterson and Cochrane (*3*) supplemented a mixture of corn, wheat middlings, barley and whey with (a) fish meal, (b) fish meal plus cod liver oil, (c) peanut meal plus minerals and (d) peanut meal plus minerals plus cod liver oil.

Their results indicate that cod liver oil had but a slight effect on the gains of the pigs, and was expensive as well. Furthermore, an oily flavour was detected, after storage, in the bacon made from the cod liver oil fed pigs.

Objects of this Trial

To secure further evidence upon this question, particularly with reference to the possible value of cod liver oil as an ingredient in the rations of young pigs housed and fed indoors from birth to market weight.

Animals Used and Management During the Trial

For this study, forty purebred Yorkshire pigs, bred at Macdonald College and ranging from nine to eleven weeks in age were selected. To compensate for the difference in age of some two weeks between the oldest and

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youngest, the forty pigs were divided into two groups of twenty each, the heavier pigs going to group A in which individual feeding was to be practised, and the lighter ones into group B to be group fed.

Groups A and B were then divided into two lots of ten pigs each, Lots I and II from Group A; III and IV from Group B.

The pigs of Lots I and II were each confined, throughout the 60-day feeding period, to separate pens, thus making possible an accurate check on the feed eaten by each individual pig, and the subsequent calculation of the gains made on the basis of known individual consumption.

Lots III and IV were housed and fed by lots, the gains per unit of feed eaten being calculated on the basis of equal feed consumption by each pig within the lot.

Rations Fed

All materials fed other than the water and cod liver oil were incorporated in the meal mixture and this consisted for all lots of:

Wheat middlings	300 pounds
Sampson feed	400 "
Supplementary protein mixture	300 "

The wheat middlings were the standard product on the market. Sampson feed is a commercial feed mixture, containing corn, barley, oats and screenings. In analysis, this product compares closely with corn meal.

The supplementary protein mixture is one prepared by the author for general use in the college piggery. It consists of:

400	pounds	high grade tankage.
200	"	fish meal.
200	"	linseed oilmeal.
100	"	bone meal.
76	"	ground limestone
20	"	salt
4	"	ferric oxide.

The cod liver oil was fed at the rate of one half ounce per pig per day. It was added once daily to the feed of the pigs in Lots I and III. Pigs were fed three times per day, the dry meal being put into the troughs and the water allowance poured over it. No attempt was made to regulate the daily feed consumption of any pig or group of pigs, other than to provide as much as would be consumed without waste.

The Data

The detail of weights and gains of the pigs, the feed consumption, and calculated gains per 100 pounds of dry feed eaten for the two 30-day periods and the full 60-day period are given in tables 1 and 2.

A summary of the salient points in tables 1 and 2 is given in table 3.

TABLE 1. *Weights, gains and feed consumption for 1st and 2nd 30-day feeding periods and total 60-day period. Lots I. and II. pigs individually fed.*

Lot.	Pig No.	First 30 Days					Second 30 Days				Full 60 Days		
		Initial Weight Aug. 24	Weight Sept. 23	Gain 30 days	Feed Eaten 30 days	Gain per 100 lbs. Feed Eaten	Weight Oct. 23	Gain 30 days	Feed Eaten 30 days	Gain per 100 lbs. Feed Eaten	Gain 60 days	Feed Eaten 60 days	Gain per 100 lbs. Feed Eaten
Lot I. ½ oz. C.L.O. daily per pig. Pigs individually fed.	1	49	93	44	142	31	143	50	218	23	94	360	26
	2	48	92	44	134	33	144	52	229	23	96	363	27
	3	45	91	46	132	35	152	61	228	27	107	360	30
	4	42	86	44	131	34	143	57	215	26	101	346	29
	5	35	67	32	93	34	123	56	190	29	88	283	31
	6	42	80	38	115	33	133	53	202	26	91	317	29
	7	32	70	38	106	36	132	62	208	30	100	314	32
	8	37	75	38	111	34	128	53	212	25	91	323	28
	9	29	64	35	100	35	117	53	194	27	88	294	30
	10	34	72	38	100	38	126	54	202	27	92	303	30
	Average initial weight				39.30 lbs.			79.00 lbs.				39.30 lbs.	
	Average daily gain				1.33 lbs.			1.67 lbs.				1.58 lbs.	
	Average daily feed				3.88 lbs.			6.99 lbs.				5.44 lbs.	
	Average gain per 100 lb. feed eaten				34.3 ± .38 lbs.			26.3 ± .46 lbs.				29.0 ± .37 lbs.	
Lot II. No C.L.O. Pigs individually fed.	1	48	90	42	122	34	151	61	184	33	103	306	34
	2	45	96	51	135	38	154	58	215	27	109	350	31
	3	43	85	42	135	31	141	56	231	24	98	366	27
	4	39	81	42	114	37	130	49	202	24	91	316	29
	5	36	84	48	122	40	137	53	218	24	101	340	30
	6	35	80	45	125	36	136	56	241	23	101	366	28
	7	32	72	40	111	36	126	54	207	26	94	318	29
	8	37	85	48	119	40	136	51	183	28	99	302	33
	9	32	61	29	104	28	103	42	207	20	71	311	23
	10	34	68	34	102	33	119	51	216	24	85	318	27
	Average initial weight				38.10 lbs.			80.20 lbs.				38.10 lbs.	
	Average daily gain				1.40 lbs.			1.77 lbs.				1.59 lbs.	
	Average daily feed				3.96 lbs.			6.35 lbs.				5.49 lbs.	
	Average gain per 100 lbs. feed eaten				35.3 ± .78 lbs.			25.3 ± .71 lbs.				29.1 ± .64 lbs.	
Differences (errors with odds of 30 to 1)	In favor of lot II				1. ± 2.77 lbs.		In favor of lot I		1. ± 2.69 lbs.		In favor of lot II		1. ± 2.34 lb.

TABLE 2. *Weights, gains and feed consumption for 1st and 2nd 30-day and total 60-day feeding periods. Lots III. and IV. pigs group fed.*

Lot.	Pig No.	First 30 Days: Initial Weight Aug. 24	First 30 Days: Weight Sept. 23	First 30 Days: Gain 30 days	First 30 Days: Feed Eaten 30 days	First 30 Days: Gain per 100 lbs. Feed Eaten	Second 30 Days: Weight Oct. 23	Second 30 Days: Gain 30 days	Second 30 Days: Feed Eaten 30 days	Second 30 Days: Gain per 100 lbs. Feed Eaten	Total 60 Day Period: Gain 60 days	Total 60 Day Period: Feed Eaten 60 days	Total 60 Day Period: Gain per 100 lbs. Feed Eaten
Lot III. ½ oz. C.L.O. daily per pig. Pigs group fed	1	37	72	35	76	46	121	49	156	31	84	232	36
	2	34	77	43	76	57	127	50	156	32	93	232	40
	3	22	42	22	76	29	86	44	156	28	64	232	28
	4	27	45	18	76	24	92	47	156	30	65	232	28
	5	27	65	38	76	50	116	51	156	33	89	232	39
	6	19	61	42	76	55	116	55	156	35	97	232	42
	7	33	65	32	76	42	125	60	156	38	92	232	40
	8	28	53	25	76	33	96	43	156	28	68	232	29
	9	33	42	9	76	12	87	45	156	29	54	232	23
	10	24	56	22	76	29	103	47	156	30	79	232	34
	Average initial weight				28.4 lbs.			57.8 lbs.				28 4 lbs.	
	Average daily gain				.95 lbs.			1.64 lbs.				1.31 lbs.	
	Average daily feed				2.53 lbs.			5.2 lbs.				3.87 lbs.	
	Average gain per 100 lbs. feed eaten				37.7 ± 2.88 lbs.			31.4 ± .64 lbs.				33.9 ± 1.32 lbs.	
Lot IV. No C.L.O. Pigs group fed.	1	29	56	27	82.5	33	104	48	160	30	75	242.5	31
	2	26	39	13	82.5	16	82	43	160	27	56	242.5	23
	3	26	55	29	82.5	35	98	43	160	27	72	242.5	30
	4	29	60	31	82.5	38	104	44	160	27	75	242.5	31
	5	25	55	30	82.5	37	109	54	160	34	84	242.5	35
	6	32	61	29	82.5	35	111	50	160	31	79	242.5	33
	7	28	65	37	82.5	45	118	53	160	33	90	242.5	37
	8	33	64	31	82.5	38	119	55	160	34	86	242.5	35
	9	33	66	33	82.5	40	112	46	160	29	79	242.5	33
	10	30	70	40	82.5	48	125	55	160	34	95	242.5	39
	Average initial weight				29.1 lbs.			59.1 lbs.				29.1 lbs.	
	Average daily gain				1.0 lbs.			1.64 lbs.				1.34 lbs.	
	Average daily feed				2.75 lbs.			5.33 lbs.				4.04 lbs.	
	Average gain per 100 lbs. feed eaten				36.5 ± 1.73 lbs.			30.6 ± .62 lbs.				32.7 ± .9 lbs.	
Differences (errors with odds at 30 to 1)	In favor of lot III 1.2 ± 10.65 lbs.						In favor of lot III .8 ± 2.82 lbs.				In favor of lot III 1.2 ± 5.07 lbs.		

TABLE 3. *Summary of tables 1 and 2.*

Items	Individually Fed		Group Fed	
	Lot I Cod Liver Oil	Lot II No Cod Liver Oil	Lot III Cod Liver Oil	Lot IV No Cod Liver Oil
Number of pigs fed	10	10	10	10
Days on feed	60	60	60	60
Average initial weight of pigs	39.3 lbs.	38.1 lbs.	28.4 lbs.	29.1 lbs.
Average daily gain				
First 30 days	1.33 lbs.	1.40 lbs.	0.95 lbs.	1.0 lbs.
Second 30 days	1.67 "	1.77 "	1.64 "	1.64 "
Total 60 days	1.58 "	1.59 "	1.31 "	1.34 "
Gain per 100 lbs. dry feed eaten				
First 30 days	34.3 ± 0.38 lbs	35.3 ± 0.78 lbs	37.7 ± 2.88 lbs	36.5 ± 1.73 lbs
Second 30 days	26.3 ± 0.46 "	25.3 ± 0.71 "	31.4 ± 0.64 "	30.6 ± 0.62 "
Total 60 days	29.0 ± 0.37 "	29.1 ± 0.64 "	33.9 ± 1.32 "	32.7 ± 0.9 "
Differences (errors on basis of odds of 30 to 1)				
First 30 days	——	1. ± 2.77 lbs	1.2 ± 10.65 lbs	——
Second 30 days	1. ± 2.69 lbs	——	0.8 ± 2.82 "	——
Total 60 days	——	0.1 ± 2.34 lbs	1.2 ± 5.07 "	——

DISCUSSION OF RESULTS

First it may be well to mention the probable errors reported in connection with the gains made in the lots and the allowance required for uncontrolled variation within the lots as expressed by the error of the differences on the basis of 30 to 1 odds.

The probable error of an average gain represents, in the case of a feeding trial, the variation which may be expected in repetition of the trial above or below the average found in the trial in question, this with odds of 50-50. The size of the error is determined by the uniformity of gains within the group. The more uniform the gains the smaller this error and hence the more reliable the average gain of the lot as an index of what may be expected of another group of animals fed and managed in the same way as the original group.

Thus the average gain of 34.3 ± 0.38 pounds (Lot I—first 30-day period) means that the chances are even that a second lot of pigs comparable to these and fed similarly (i.e., a repetition of this trial) would show an average gain somewhere between 33.92 and 34.68 pounds. To one familiar with hog feeding it also means that the gains of the pigs in this lot were exceedingly uniform in proportion to the feed eaten per pig.

Admittedly "even chances" are not certain enough for the feeder. The odds must be in his favour to be of much value in feeding operations. To raise the odds or to increase the certainty that repetition of a trial will give results similar to the original, it is simply necessary to increase the size of the probable error. That is, to widen the gap between the minimum and maximum gains expected.

Odds of 30 to 1 are considered as practical certainty and by multiplying the probable error by 3.17 the allowance for uncontrolled variation within the group is sufficiently large to give these odds.

Therefore, while the probable error figure attached to the average gain per 100 pounds of feed eaten is of value in indicating the uniformity of gains within the lot, when the differences between the two comparative lots are considered we need to know with some certainty whether upon repetition of the trial, we may expect the same results. This certainty is obtained by calculating the probable error of the difference and then increasing it 3.17 times to give odds of 30 to 1.

The errors attached to the differences in this trial, then, represent the amount of difference in pounds which would have to exist between the average gains of the comparative lots *before any difference could correctly be credited to the effect of the cod liver oil.* Differences in excess of the error may be legitimately credited to the imposed experimental condition being studied.

In this trial there was in no case a difference found between comparative lots (i.e., Lot I vs. Lot II and Lot III vs. Lot IV) as large as the error involved, which means that the effect, if any, of cod liver oil was so small that it could not be measured in this trial.

The fact that the differences themselves were very small, and that in the individually fed lots they were not consistantly in favour of the same lot is suggestive that the addition of cod liver oil to a ration similar to the one used in this trial is of questionable value.

In the group fed lots the results are all in favour of the cod liver oil fed group but the errors are so large that no significance can be attached to this fact.

As to why the use of cod liver oil showed no significant results in this trial, is, of course, a matter of conjecture. It would seem entirely possible, however, that the use of fish meal as one of the ingredients of the ration might be a factor, on the basis that fish meal made from entire fish may contain appreciable amounts of vitamin D. (It has already been shown that liver oil from at least one fish other than the cod is a far more potent source of vitamin D than is that from cod livers) (*4*).

Group vs. Individual Feeding

This trial illustrates very nicely the advantages of individual feeding over group feeding in comparative feeding trials. That pigs, and other animals as well, are exceedingly variable in their response to imposed experimental conditions has been accepted by feeders, particularly experimentalists, as one of the necessary evils attending the work. And to a certain extent this attitude is justified.

The results of studies by the author on this problem (*5, 6*), however, indicate clearly that live weight gains are closely correlated with feed consumption and that much of the variability found in gains per unit of feed eaten is really due to the practice of assuming that each pig of a group eats his proportionate share of the total feed of the group.

When any method of feeding is followed in which the actual food consumption of each of the individuals of the lot is recorded and used in calculating the gains per unit of feed eaten (or feed required per unit of gain)

there is generally a striking reduction in the variability of these calculated gains. Of course, it is entirely likely that in some cases pigs which are group fed will eat very similar quantities of food throughout the trial, in which case the use of group data will not introduce a serious error. But in the majority of trials with pigs there will be found the odd individual that proves a poor feeder, or which for a few days, goes "off feed". There is no way in which this situation can be compensated for in group feeding and it is therefore disregarded excepting as his actual progress tends to lower the average of the group.

Individual feeding records show that even the poor feeders gain pretty much in proportion to the feed they actually eat.

Hence an average gain per unit of feed eaten found in a group of pigs in which this gain is based upon actual rather than calculated feed consumption is more reliable than is possible to realize in group feeding practice.

Summary

1. As a supplement to the rations used in this trial, cod liver oil, fed at the rate of ½ ounce per pig per day, failed to affect measurably the live weight gains of the pigs to which it was fed as indicated by the progress of comparative lots not receiving this product.

2. Its use, therefore, as a regular ingredient of the daily rations of thrifty, growing pigs would seem unwarranted.

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ALFALFA AS A FORAGE CROP FOR WESTERN CANADA*

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In the pioneering stages of agriculture in new countries, cereal crops are generally grown almost exclusively, the native vegetation being utilized to provide pasture and hay for the few animals which are indispensable to the pioneer. In the case of dry prairie areas, ranging is likely to be the pioneer type of agriculture if indeed this can rightfully be termed agriculture at all. In either case, however, forage crops produced under methods of culture are conspicuously absent. But as the country develops, as population grows with towns and cities, and as the land becomes depleted of its virgin fertility with consequent reduction in its production, it becomes necessary to institute and develop live stock production to meet the demands for animal products and to assist in replenishing the lost fertility of the soil. Live stock production demands abundant supplies of forage crops both in the form of pasture and preserved food for winter use.

In the more settled portions of Western Canada cereal production has been the chief interest of our farmers since the beginning and will probably continue to be for years to come. But the live stock industry is growing, particularly in the irrigated areas and in the long grass area that extends across the prairie provinces. And just as the grain growing phase of agricultural development in Southern Ontario, for example, has been replaced by the "climax phase", so to speak, in which the grain growing, fruit production, poultry and live stock industries have reached a condition of more or less permanent balance for the general conditions of Southern Ontario, so we may expect that in Western Canada, agricultural development will steadily move towards a "climax phase" in which the various agricultural industries possible to the climatic and other conditions, will assume a more or less permanent though fluctuating balance. This "climax phase" of Western Canada agriculture will undoubtedly involve a great animal industry and this will necessitate a very extensive production of forage crops. The present stage even, of agricultural development in the prairie provinces presents a growing and fairly extensive live stock industry which is calling for more forage crops, and particularly in dry seasons like that of 1929 the deficiency of abundant forage is very keenly felt. Hence, if the live stock industry is to develop, and if agriculture in general is to progress satisfactorily toward the so-called "climax phase" of stability, forage crop production must keep pace with the demands of the times. If adequate forage crops are to be continually available the greatest technical knowledge and skill possible must be applied to the choice of forage crops to be grown in the various agronomic zones, and to the most economical and efficient methods of production and utilization. It would seem that alfalfa, which is playing an outstanding part in the agricultural economies of other parts of the world and which is so highly commended for its excellence as a forage crop, ought to receive more consideration in the agriculture of Western Canada than it has hitherto done.

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But alfalfa is by no means excluded at present from our Western Canada agriculture nor from Canadian agriculture in general. According to the Canada Yearbook, 1929, the acreage in alfalfa has increased from 97,000 acres in 1911 to 910,156 acres in 1927, and according to the annual report of the Department of Agriculture of Alberta for 1928 the acreage in alfalfa has ranged from 2,592 acres in 1910 to 40,925 acres in 1928. In 1926 the province had its maximum acreage of 52,700 acres while in 1927 and 1928 the acreage fell off by about 11,700 acres. Parallel figures for Saskatchewan and Manitoba were not available at the time of writing. This drop in acreage in Alberta was regrettable and was due to several circumstances chief of which were the low price of alfalfa hay, the high price of wheat and the greatly increased use of sweet clover as a forage crop. We have made a good beginning in alfalfa production in Western Canada, but it would seem that the present circumstances would warrant a very substantial increase in the production of this crop.

A few of the advantages of growing alfalfa may now be briefly referred to.

1. Alfalfa is generally conceded to be the best forage crop in existence for temperate parts of the world in regard both to yielding capacity and feeding value. Its rapid rate of growth where drought is not a serious handicap makes possible from two to four cuttings in Canada (six or more in regions with longer growing seasons). This feature of rapid growth is also of great importance in any consideration of its value as a pasture plant.

In Canada as a whole according to the Yearbook, 1929, the average yield of alfalfa as a hay crop for the years 1918-1927 was 2.5 tons per acre while for other hays and clover the yield was 1.5 tons per acre for the same period. The following table compiled from the above mentioned Yearbook may serve to compare the average yields of alfalfa and of hay and clover for Manitoba, Saskatchewan and Alberta for the 10 year period 1918-1927.

Average Yields in Tons per Acre

	Alfalfa	Hay and Clover
Manitoba	2.2	1.7
Saskatchewan	2.1	1.4
Alberta	2.3	1.2

Allowing for the probably greater acreage of alfalfa than hay and clover crops under irrigation particularly in Alberta it would seem safe to conclude that on the average alfalfa may be expected to yield at least 50 per cent more cured hay in the prairie provinces than the ordinary hay grasses and clovers.

Regarding the superior feeding value of alfalfa little need be said though much has been written which is based on chemical analyses and feeding tests. Its superiority lies chiefly in its greater protein content and in the quality of its mineral content. According to Stewart (*11*) the cured hays of grasses and legumes do not differ materially in the total minerals carried but in quality they differ widely. Alfalfa contains 7.2 per cent ash and timothy 6.8 per cent. A great portion of the ash of timothy is silica, a mineral almost useless to animals. Lime is about 6 times as abundant in

alfalfa hay as in timothy. The great difference in lime content between the alfalfa hay and the timothy hay makes the alfalfa much more valuable for feeding especially when fed with grain.

2. The alfalfas have a remarkably wide range of adaptability to climatic and soil conditions. They probably exceed the wheats in this respect. The fact that the alfalfas, one variety or another, are naturally distributed over a wide range of conditions in the old world and that they are grown under cultivation in every state of the United States and in every province of Canada bears witness of its wide adaptability to climatic conditions particularly.

The deep rooting system is one of the unique features of the alfalfa plant, which is of great significance in relation to the ability of alfalfa to survive and flourish in areas of comparatively light rainfall. Alfalfa thrives on a great variety of soils from sands and gravelly loams to silts and clays providing there is good drainage, abundance of lime and mineral nutrients and that the proper bacteria are present.

3. It has been very clearly demonstrated that alfalfa grown on lands that are low in nitrogen will tend to increase the nitrogen content of the soil up to a certain level. Sir John Russel (*7*) discussed experimental data bearing on this question and reached the conclusion that poor soils are considerably enriched by growing alfalfa even when the hay was removed, but, "the gain in nitrogen does not go on indefinitely; in the course of time a point is reached, higher or lower, according to the soil conditions where further gains are balanced by further losses, so that nitrogen content remains constant." This view, that soils very poor in nitrogen are considerably built up in that nutrient when made to grow a crop of alfalfa, is the view now generally held by soil scientists. As old alfalfa fields are ploughed up, the alfalfa roots decay rapidly if there is sufficient moisture and a large supply of nitrogen becomes available in a short time and hence the grain crop following alfalfa is likely to show a very vigorous growth even to the extent of lodging in some cases.

Stewart (*11*) states "In dry regions the decaying roots of alfalfa improve the soil quite apart from the nitrogen they contain by adding large amounts of organic matter. Moreover the roots have penetrated several feet into the subsoil opening up channels both for aeration and water. Improved tilth, especially of heavy land, is very noticeable for three or four years after alfalfa."

4. Alfalfa is a relatively cheap crop to produce. This is true if a good alfalfa stand is allowed to remain for four or five years though the cost of establishing a stand is greater than for most other forage crops. It is a case of alfalfa costing more at the start but paying better in the long run—a prospect which appeals to the permanent farmer but not to the "soil miner".

Stewart (*11*) reports Boss and his co-workers at the Minnesota Agricultural Experiment Station in regard to the comparative costs of production for alfalfa and for tame hay (timothy and clover) on the basis of a five year period, 1920-1924 in which the cost of starting the alfalfa was distributed over this period of time. These investigators found that while

alfalfa cost more per acre to produce than tame hay it cost less per ton on account of its yield being about double that of the tame hay. It was found that the cost of producing an acre of alfalfa hay ranged from about 37 to 43 per cent of the value of the crop per acre while for tame hay the cost per acre ranged from 60 to 104 per cent of the value of the crop per acre. These figures illustrate clearly the much lower relative cost of producing alfalfa hay than of producing tame hay. Incidentally it may be said that the net profits for alfalfa were from about $18.00 to about $33.00 per acre while for tame hay the net profits were from nothing to about $8.00 per acre. These figures no doubt accurately represent the situations cited, but they might not hold for present day values. However, there is no reason to believe that the decided balance favouring the relatively low cost of production of alfalfa would not obtain generally.

5. Alfalfa is a serviceable crop to eradicate certain serious weeds. This is particularly true for Canada thistle and wild oats, as well as for many other weeds whose seeds are unable to lie dormant for several years in the soil. The early and frequent cuttings of alfalfa destroys annual weeds before they have had an opportunity to flower and set seed. This of course applies to those areas where the stand of alfalfa is good. If areas occur in the field where the stand is too thin and too extensive to warrant cutting, weeds may flourish in these areas and become a menace. In cases of this kind the eradicating virtues of alfalfa are counterbalanced by the conditions in the killed-out areas which decidedly favour propagation.

In the preceding an effort has been made to call to mind a few considerations concerning the place of alfalfa in general, as well as in Western Canada agriculture and to recall a few of the specific advantages of alfalfa as a crop. I should like now to mention a few of the problems involved in alfalfa production particularly in Western Canada and to discuss very briefly the progress that has been made toward the solution of these problems.

1. *Winter hardiness.*—Although alfalfa has had a phenomenal development in its distribution to widely separated parts of the world during the past century its conquest so to speak of Canada and Northern United States has been retarded until recent years by the unforunate use of seed of non-winter hardy varieties. Common alfalfa was found to be adapted only to the southern and mild portions of the United States and consequently strains were sought suitable for the colder and drier parts with the result that many regional seed stocks were imported from Asia and Europe. Some of these, Turkestan for instance, at first proved very satisfactory and immediately a demand for Turkestan seed arose with the result of large importation. Much of this seed was inferior and many farmers were disappointed and naturally became prejudiced. Similarly for other non-hardy varieties many farmers acquired the impression that alfalfa was not hardy enough for Canada and the colder portions of the United States. But hardy strains particularly of the variegated types have been imported and developed by processes of selection so that at the present time such very hardy strains as Grimm, Ontario Variegated, Cossack and Baltic have proven themselves to be generally suitable for our coldest agricultural districts.

Growing tests for different varieties and strains have been conducted by the Dominion Experimental Farms and the various Agricultural Colleges throughout the country. Zavitz (*12*) found in a ten year experiment that the Grimm, Ontario Variegated, Baltic and Mongolian varieties were relatively hardy while the Common, Peruvian and Arabian varieties showed very weak resistance to cold. Mongolian was the most hardy strain and it is interesting to note that it was very slow to start growth in the spring. This would suggest a possible relation between earliness to start growth in the spring and susceptibility to so-called winter killing.

Bark (*2*) expressed the opinion that most winter killing in the Brooks district of Alberta is really spring killing. Warm spells start growth and subsequent cold weather freezes the plants and kills them. He thinks not many plants can start spring growth several times each spring and be retarded each time growth starts by severe freezing.

Steinmetz (*10*) made a study of the relative winter hardiness of Grimm representing a hardy variety and of Common Kansas alfalfa representing a non-hardy variety in order to ascertain some ready means for distinguishing hardy and non-hardy varieties. He found that alfalfa plants have no antonomous rest period. During every month plants could be brought from the field into the greenhouse and growth would start in three days. This has a bearing on the observation that warm spring spells induce alfalfa plants to start growth. Steinmetz found that resistance to cold increased in the roots of both varieties as winter approached and disappeared with the approach of spring. The hardy variety was found to contain more sugar expressed in terms of total carbohydrates than the less hardy variety. Temperatures taken at the soil surface beneath the snow indicated that snow provides ample protection for alfalfa plants against killing by low temperatures. Steinmetz found further that freezing injury resulted in the destruction of the central part of the root and left it susceptible to infection by decay organisms. The crown buds were more hardy than the root tissues immediately below them. These findings of Steinmetz regarding the nature of winter killing harmonize with Bark's opinion that most winter killing in the Brooks district is really spring killing. Steinmetz offers as the most practical and reliable method of measuring differences in hardiness between varieties, the freezing of potted plants or roots removed from the soil.

Summarizing our remarks on the problem of winter hardiness it may be said that different varieties and strains possess very marked differences in cold resistance, that good agronomic strains exist which are satisfactorily hardy for Western Canada, that the so-called winter killing is mostly spring killing resulting from the freezing of plants which have lost their resistance to cold and have perhaps started growth activities, and that a practical and ready method of testing the relative resistance of varieties and strains has been suggested by Steinmetz which involves the freezing of potted plants or roots removed from the soil.

2. *Seed setting.*—Experienced alfalfa seed growers are familiar with the fact that the seed crop is a matter of great uncertainty. This uncertainty and the frequent light seed crops have resulted in a high price for good alfalfa seed as compared with sweet clover seed, for instance. The high price of seed has undoubtedly been an important factor in restricting the general

production of the alfalfa crop. The cause of seed failure has been a matter for much controversy and speculation.

Seed failures have been attributed directly to unfavourable conditions of soil moisture and plant food, to unfavourable atmospheric or weather conditions at critical stages of growth, to lack or scarcity of the proper bees to effect tripping and to the hybrid constitution of the varieties in common use.

Attempts have been made to modify the methods of planting, for instance spacing rows in order to permit the crop to receive more air and sunlight; but this is not always successful. In moist soils the plant continues its vegetative growth and fails to produce seed. This also is liable to occur in heavy soils. However, the knolls of heavy land sometimes produce a good setting of seed while the intervening hollows fail. On irrigated lands the water supply has been manipulated with a view to supplying the proper soil moisture conditions. Martin (*6*) studying this problem as a botanist and Alter (*1*) as a meteorologist came practically to the same conclusion, viz., that failure to secure a properly balanced supply of soil and atmospheric moisture is the real cause of alfalfa flowers refusing to set seed. Southworth (*9*) found that alfalfa flowers which were not tripped did not set seed. Hence it would seem that a proper soil, atmosphere moisture balance and tripping are necessary for seed setting.

A number of investigators have sought to solve the practical difficulty by selection of individual plants which have proved to be heavy setters of seed. A few improved strains have in this way been acquired but they are as yet not widely known commercially. Kirk (*5*) studied selfed lines of alfalfa. In general there was a reduction in vigour of growth but he found a few selfed lines which were not significantly different in yield from the corresponding open-fertilized strains. He also found selfed lines which compared favourably with the original material in the amount of seed produced. A significant correlation was obtained for the relationship of seed setting between first and second generations of selfed lines which indicate that the characters of high and low seed production are to some extent inherited. This suggests that further improvement in securing good seed setting strains of alfalfa is reasonably to be expected. Southworth (*8, 9*) has attacked the problem by means of hybridization, his objective being to secure an alfalfa plant which would have good pasture qualities and at the same time set an abundance of seed. Using alfalfa as the female parent and black medic, *Medicago lupulina,* as the male parent he succeeded in spite of the difficulty of this cross in securing F_1 and subsequent generations. His object in using black medic was to secure a hybrid derivative race which would set seed by automatic tripping of the flowers as is the case in this species. Numerous sib-matings and back crosses were made in the different generations and he obtained some plants with flowers which were practically entirely self-tripping but largely sterile and also some other plants which were partially self-tripping and partially fertile. He also found that sterility appeared to be giving place to fertility in the more recent generations and he concludes therefore that there is reason to hope that eventually a strain will be evolved having flowers perfectly self-tripping and also possessing a high degree of fertility. The writer might say that he has personally grown some of Professor Southworth's F_5 and F_6 generations in the greenhouse and while

some of the plants were sterile others produced a very heavy setting of seed without any of the flowers being tripped by bees or by hand.

It may then be said regarding the problem of seed setting in alfalfa that while the problem is still unsolved from the practical standpoint, it seems to have been at least partially analyzed and diagnosed, and at the present stage of its solution the indications are that some practical improvement is to be expected by applying methods of line selection and possibly interspecific hybridization.

3. *Getting a stand.*—The first year of the life period of a stand of alfalfa is the most critical one and probably the hazards of this period are responsible to some extent for deterring many farmers from growing alfalfa. Much experimentation has resulted in the establishment of quite definite practices for general and for particular regional conditions. For example, in the various districts of Western Canada fairly definite practices have been found to be best by the local experimental stations for the districts. The problem here appears to be largely an educational one. The technical aspects of the problem involving choice of variety, choice of land, seeding, inoculation, seeding with or without nurse crop, weed control, etc., would seem to have been pretty well determined for specific regions and it would appear to be a matter of educating growers to the necessity of following carefully the approved practices.

4. *Curing alfalfa hay in moist districts.*—The seasonal distribution of rainfall in the prairie provinces is in general a most fortunate one from the standpoint of growing crops, particularly cereal crops, but in the moister parts the frequent rains in June and July are very detrimental to curing the first cutting of alfalfa hay. This is a difficulty frequently experienced in the Edmonton district, for instance. It is undoubtedly a serious difficulty for growers who wish to commercialize their hay directly on the basis of standard grades. For the grower who wishes to feed his hay it would seem to the writer on theoretical grounds a feasible practice to grow alfalfa and western rye grass or awnless brome grass in mixture and ensile the mixture rather than to attempt to cure the hay in the usual way. This might be done for cuttings which on account of rains were unlikely to be satisfactorily cured. Other cuttings which appear likely to escape rains might be cured in the usual way and stacked or stored. The cost of silos might, however, be a serious objection to this practice, and the extra cost of handling would also be a serious matter to consider. Silage of this material should, however, be of excellent value for any kind of live stock.

Stewart (*11*) in discussing the problem of curing alfalfa hay emphasizes the importance of handling the crop in such a way as to minimize the loss of leaves. He points out that curing, which is drying, should be done slowly in order that the leaves may not dry out quickly and fall off while the stems have still a relatively high moisture content. He states that "for arid and semi-arid regions the farmers are more and more adopting the practice of curing in the windrow and cock rather than in the swath. This permits the gradual reduction of moisture through the leaves in such a manner that the leaf-petioles are kept functioning. The leaves then do not dry too rapidly and fall off. In the end the hay is cured about as rapidly and the leaves are preserved".

In rainy seasons, however, this procedure may extend the curing period unduly and necessitate excessive labour in turning cocks to facilitate drying and it would seem desirable under these circumstances to swath dry partially before windrowing and cocking.

5. *Bloating of cattle and sheep when alfalfa is used for pasture.*—Many farmers are much afraid of loss of these classes of live stock if alfalfa is pastured and they doubtless have grounds for their fears. Horses and hogs do not appear to be subject to bloating from this cause and hence the problem does not apply to them. This danger of bloating is undoubtedly a serious handicap to the use of alfalfa for pasture purposes, but it applies also to pasturing sweet clover or red clover. Losses are usually due to ignorance of or carelessness in observing the cautions that must be taken to avoid bloating. The problem here seems again to be one of education and the observance of well established practices. However, in spite of careful observance of rules to prevent bloating, animals are apparently sometimes lost, but if one could estimate the proportion of animals lost through this cause where reasonable precautions had been taken to avoid such losses it would likely be a very low and practically insignificant proportion in comparative consideration of the great value of the crop for pasture. It has been suggested that the dangers from bloating might be materially reduced by using mixtures of alfalfa and suitable grasses instead of pure alfalfa. This might be of some advantage, but it would seem necessary to have the grass constituent quite prevalent and evenly mixed in the stand.

6. *Morphological variability in relation to registration.*—The registration of any particular variety of alfalfa in Canada is at present a difficult problem due to the extreme variability of any strain so far produced, to the difficulty of laying down definite morphological standards and to the difficulties inspectors have in distinguishing with certainty plants which may not be merely environmental variations of the pure variety. These difficulties are not readily appreciated by the agriculturist who is unfamiliar with the genealogical relations of the alfalfa races of plants and who perhaps also desires standards of a precise, "cut and dried" nature laid down and observed to the letter by the inspection officers. Here again educational efforts may be needed to emphasize sufficiently the complex constitution of the alfalfa plant as a result of its complicated evolutionary past. Not that this complex constitution can at present be unfolded but rather that its complexity may be sufficiently appreciated. It is, of course, highly desirable that we should understand the genetical complexity of the varieties of alfalfa we are interested in but this involves intricate problems for future research. In the meantime it would seem reasonable to insist that registration standards and inspection regulations should not be made in advance of well established knowledge of practically identifiable characteristics of any particular variety that may be under consideration.

However, as time goes on varieties will no doubt be developed through breeding methods which for definite characters will breed true and which can be fully identified. When such varieties are obtained more exacting standards of registration may then be adopted so long as they permit of practical application.

Conclusions

Other problems relating to alfalfa production might be mentioned and discussed as for example "hard" seeds, maintenance of a stand against the encroachment of weeds, diseases, etc., but they are more or less minor problems and will not be discussed here.

In this paper the writer has sought, to sketch the historical development of alfalfa as a crop, to point out the place of alfalfa in general agriculture and in the "climax phase" of agriculture in Western Canada, to recall some of the outstanding advantages of alfalfa as a forage crop and to discuss some of the major problems which the growing of this crop presents and the progress that has been made toward the solution of these problems.

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A NEW "DWARF" OAT

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An interesting new oat form was found in 1927 in the Peace River country by Mr. Herman Trelle, on his farm at Wembley, Alberta. This rather peculiar type appeared in a registered stock of Victory oats, selected by himself from seed obtained some years previously from Dr. Seager Wheeler of Rosthern, Saskatchewan.

The specimen as found by Mr. Trelle represented one plant, described as having very stiff straw, a little shorter than normal Victory and having a somewhat reduced panicle. Mr. Trelle sowed the seed of this plant in a head row adjoining a number of head rows of wheat in the spring of 1928. It was here that Mr. L. H. Newman, Dominion Cerealist, noticed it when on a visit to Mr. Trelle's farm on August 24th, 1928. Observing the peculiar characters and variability of the plants within this row, Mr. Newman asked Mr. Trelle for a few specimens and was promptly advised that he might have the entire row. As the plants were then ripe, the whole row was pulled and forwarded to Ottawa where it has been under observation by the writer for two seasons.

There have been comparatively few cases reported of dwarfing in oats, and amongst the literature available, none seems to be directly traceable to mutation.

Warburton (*1*) found dwarf oat plants appearing in a strain of Victory. These plants were apparently true dwarfs and were not only very late maturing but produced very little seed. The segregation of normal talls to dwarfs was very close to a 3:1 ratio, indicating the presence of a single factor for dwarfness.

Stanton (*2*) reported dwarf oat plants appearing in selections from hybrid material. In the case of dwarfs found in one hybrid selection, it was suggested that on the basis of segregation, dwarfness was behaving as a pure recessive similar to the dwarfs reported by Warburton. Other dwarfs found among re-selections from another hybrid family, indicated that dwarfness was dominant, as the segregation showed an approximate ratio of 3 dwarfs to 1 tall. Stanton (*2*) suggests that the appearance of the apparently heterozygous dwarf may have been due to a mutation within a pollen, or an egg cell of a normal plant.

Goulden (*3*) found dwarf oats appearing among some plants heterozygous for the false-wild character. These, however, were sterile. No explanation is offered as to the origin of these dwarf plants but it is pointed out that there appears to be "intimate correlation between dwarfing, the false-wild character, cytological irregularities and complete sterility".

Many references to dwarfing in other crops have been reported, some of which more or less parallel the case herein described. Waldron (*4*) describes some very interesting dwarf forms appearing in a cross between

*Cerealist.

Marquis and Kota wheats. While some of these forms appeared quite simple in inheritance, indicating a single factor for dwarfness, others gave very complicated ratios.

Cutler (*5*) reports dwarf wheat plants appearing in Marquis wheat. In this case intermediate plants segregated into normals, intermediates and dwarfs in a 1:2:1 ratio.

In the case of dwarfness appearing in a soy bean hybrid described by Stewart (*6*), the dwarf showing up in the F_3 proved to be recessive to the normal type in inheritance and the talls segregated into a ratio of 3 talls to one dwarf.

Description and Inheritance

The progeny of the plant found by Mr. Trelle in 1927 and grown on his farm in 1928 was classified into three quite distinct types. Out of a total of 49 plants brought to Ottawa, there were 17 apparently normal Victory, 22 intermediates and 10 dwarfs.

Following is a brief description of the three types mentioned above:

Normal plants—average length of straw 37.3", range 27-42"; straw not twisted, average length of internode of main tiller 6.04"; very light pubescence at upper node; panicle length and branches averaging about 6" and 3" respectively; rachis slightly lax; texture of outer glumes normal; basal and rachilla hairs absent; rachilla ranging from 1.8 to 2.2 mm. in length; grains fairly short, plump, blunt and well filled; often 3 grains per spikelet. A few heads with traces of weak awns .

Intermediate plants—straw short to medium length, ranging from 24"-34" not usually twisted; average length of internode of main tiller 5.79"; panicles and branches averaging about 5.5" and 1.75" respectively; rachis straight and stiff; texture of outer glumes usually normal; basal and rachilla hairs absent; rachilla ranging from 2.2 to 2.4 mm; grains short, plump with a full crease, generally two grains to the spikelet, occasionally three; only traces of awns found.

Dwarf plants—straw 20"-25" long, very stiff and usually twisted; average length of internode of main tiller 5.07"; light pubescence at upper node; panicle and branches averaging about 3.5" and .75" respectively; rachis straight and very stiff; texture of outer glumes inclined to be hardened and in some cases these glumes are missing entirely; basal and rachilla hairs absent; rachilla ranging from 1.4 to 2.5 mm in length; grains short, plump, blunt and well filled, usually only two in a spikelet; awnless. The leaf blades are reasonably wide and usually leave the culm at an approximate right angle after heading. This character is quite distinctive and peculiar to the dwarf type.

The dwarf type, therefore, is characterized chiefly by very stiff but rather short straw, the horizontal position of the leaves after heading, the shortened internodes, short panicle and panicle branches, hardened outer glumes and further, the peculiar formation of spikelet and inflorescence; the latter being extremely variable. The number of stamens is not constant

and the latter are often completely out of place, being found between the palea and the outer glume in which case, however, the stigma is usually absent.

Inheritance

Of the total mixed progeny obtained from Mr. Trelle, seed was sown in the greenhouse from 17 normal plants, 21 intermediates and 9 dwarfs. Twenty-two seeds from each plant were sown, making a total of 1034 seeds. Both the normals and dwarfs bred true, while the intermediates segregated into the three types—normals, intermediates and dwarfs.

In table 1 the segregation of the progeny of the 21 intermediate plants as grown in the greenhouse during the winter of 1928-29 is shown.

Table 1.

Phenotypes	Observed	Expected	Observed Ratio	Theoretical Ratio	Probable Error
Normals	100	107.25	.94	1	±6.05
Intermediates	214	214.50	1.99	2	±6.99
Dwarfs	115	107.25	1.07	1	±6.05
Total	429	429.00	4.00	4	

In 1929, seed from the normals, intermediates, and dwarfs, were sown in the field and small progenies were obtained from 120 normal, 209 intermediate and 32 dwarf plants. The normals and dwarfs again bred true, while all the intermediates except nine segregated into the three types. These nine which did not segregate produced all normal plants. It is assumed that these had been wrongly classified as intermediates in the previous generation and have not been included in table 2.

Table 2.

Phenotypes	Observed	Expected	Observed Ratio	Theoretical Ratio	Probable Error
Normals	769	774	.99	1	±16.28
Intermediates	1568	1548	2.02	2	±18.78
Dwarfs	759	774	.98	1	±16.28
Total	3096	3096	3.99	4	

Discussion

From the data presented above in connection with the study of dwarfness, it seems clearly evident that only a single factor difference is involved for the dwarf character and while it is not possible to prove the origin of this abnormal type, it is easily conceivable that it occurred as a factor mutation.

In some preliminary cytological studies with this dwarf type carried on by Dr. Lillian Hollingshead, at the Dominion Rust Research Laboratory, Winnipeg, the behaviour during the meiotic stage seemed quite normal. Several counts were made which showed 21 bivalent chromosomes at the first meiotic metaphase.

This new "dwarf" form is being crossed with normal Victory as well as with the homozygous tall segregate in order to trace in more detail its genetic composition.

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INFLUENCE DE LA CHUTE ATMOSPHERIQUE SUR LE POURCENTAGE D'ECALE DANS L'AVOINE*

ROBERT RAYNAULD †

Nombre de facteurs, on le sait, influencent le pourcentage d'écale dans l'avoine. C'est ainsi par exemple que la variété, la date de semis, etc., jouent un rôle des plus importants dans ce domaine. Dans un travail que nous avons entrepris sur le sujet, nous avons été grandement intéressés par l'influence du facteur humidité et nous voulons exposer dans les quelques lignes qui suivent nos conclusions.

A la Station du Wisconsin (*2*), des échantillons de 7 variétés d'avoine, en 1905, produisirent en moyenne 71.97% d'amande, tandis que ces mêmes variétés, en 1907, une année beaucoup moins favorable pour cette production ne donnèrent plus que 66.25% d'amande.

Warburton (*4*), de la station du Montana, obtient, en 1906, 75.79% d'amande et l'année suivante, 71.81% seulement avec 6 variétés d'avoine cultivées avec irrigation.

Kiesselbach (*1*) assure que la culture de l'avoine convient spécialement à une région ayant une saison humide telle qu'on en trouve dans les Etats du Nord, au Canada, en Angleterre et en Ecosse.

Stoa (*3*) est du même avis et déclare que l'avoine mûrissant au cours d'une longue période de végétation donne un produit de haute valeur tandis que la récolte produite pendant une saison courte, chaude et humide donne une récolte de qualité inférieure. "Les avoines cultivées dans le Nord, dit-il, sont généralement plus pesantes que celles cultivées ailleurs."

Wiggans (*5*) déclare que les conditions saisonnières amènent de profondes différences dans le pourcentage d'écale et que le climat exerce une plus grande influence sur le pourcentage d'écale que ne le fait la variété.

RESULTATS DU COLLEGE MACDONALD

L'étude de ce problème dans le présent article porte sur un groupe de 40 variétés expérimentées au collège Macdonald durant la période 1908-1918. L'auteur divise cette période en années sèches et humides, en omettant 1911, semis très tardif, et 1912 et 1913, où l'expérience fut momentanément suspendue. La moyenne du pourcentage d'écale pour les années sèches fut de 28.87%. La moyenne du pourcentage d'écale pour les années humides fut de 27.68%.

La différence dans le pourcentage d'écale entre les 4 années sèches et les 4 années humides fut donc de 1.19% en faveur de ces dernières.

L'étude de l'influence de la précipitation atmosphérique sur la proportion d'écale a été poussée plus loin. L'auteur compara les 4 années les plus sèches avec les 4 plus humides, les 3 plus sèches avec les 3 plus humides, les 2 plus humides et la plus sèche avec la plus humide.

*Résumé d'un chapitre d'une thèse sur "l'Etude des Facteurs Influençant le Pourcentage d'Ecale dans l'Avoine". Présentée à la Faculté des Etudes graduées et des Recherches, Université McGill, pour l'obtention du M.S.A.

†Rédacteur à "La Terre de Chez Nous", Organe officiel de l'U.C.C.

Comparaison du pourcentage d'écale d'aprês les années les plus humides et les plus sèches.

LES PLUS HUMIDES			LES PLUS SECHES		
Nombre d'annees	Précipitation (pouces)	% d'Ecale	Nombre d'Années	Précipitation (pouces)	% d'Ecale
4	13.791	27.68	4	8.351	28.87
3	14.348	27.24	3	7.995	28.12
2	15.105	27.35	2	7.435	28.39
1	15.844	27.20	1	6.895	28.79

Dans tous les cas, le plus faible pourcentage d'écale se rencontra avec les années humides.

L'influence de la chute atmosphérique mensuelle fut également étudiée. Le but visé était la découverte de la période critique où la présence de l'humidité pour la production de l'avoine se fait le plus senir en tant qu'il s'agit de la qualité du grain. Les mois furent donc classés en humides et secs comme plus haut. Nous nous contenterons de faire part au lecteur des conclusions que nous avons obtenues:

Mai

Le pourcentage d'écale le moins élevé fut obtenu avec les mois de mai les plus secs. Il ne faut pas oublier cependant que le semis très souvent vient à peine d'être terminé à la fin de ce mois.

Juin

Les mois de juin les plus humides résultent en un faible pourcentage d'écale. Dans certains cas, cependant la différence est très peu marquée.

Juillet

La conclusion est la même que pour le cas précédent et les différences sont beaucoup plus sensibles qu'en juin.

Nous faisons paraître nos chiffres car nous pensons qu'ils sont tout à fait significatifs:

Comparaison du pourcentage d'écale d'aprês les mois de juillet les plus humides plus secs.

LES PLUS HUMIDES			LES PLUS SECS		
Nombre d'années	Précipitation (pouces)	% d'Ecale	Nombre d'années	Précipitation (pouces)	% d'Ecale
4	3.459	28.16	4	1.438	29.22
3	3.742	28.38	3	1.310	29.63
2	3.965	27.29	2	1.215	30.05
1	4.045	27.00	1	1.093	29.00

Août

De l'étude de ce mois on ne peut rien conclure car les résultats obtenus sont très variables.

Discussion

Dans les différentes étapes de cette étude nous avons constaté une tendance presque continue vers un faible pourcentage d'écale quand la chute atmosphérique était élevée. On ne pourrait aisément découvrir cependant

quelle est la période critique dans la production de l'avoine. L'humidité est-elle nécessaire durant toute la saison de végétation pour l'obtention d'une avoine de haute qualité ou celle-ci est-elle causée surtout par la chute atmosphérique durant un mois spécial de la saison de végétation?

Pour parvenir à obtenir quelques éclaircissements sur la question, nous avons décidé de comparer le pourcentage d'écale obtenu durant 2 années sèches typiques, deux années humides typiques et une année sèche et une année humide. Le même travail fut fait avec les différents mois.

Conclusions

En ce qui concerne les années, rien de définitif.

Nos résultats pour mai, juin et août ne furent pas convaincants. Mais la proportion d'écale fut de beaucoup moindre avec le mois de juillet humide.

Varietes Hatives

On se le rappelle, tout ce qui précède regarde un certain groupe de variétés qu'on est convenu de regarder comme mi-tardives. Mais il se pourrait que les variétés reconnues comme hâtives se comportent d'une façon différente.

L'Alaska (G) a été choisie comme représentant une variété type de ce groupe. L'analyse que nous en avons faite couvre la même période d'années et la même procédure a été suivie. Nos conclusions furent les suivantes:

1) Une différence de 1.80% dans le pourcentage d'écale se rencontre en faveur des années humides quand on considère les années sèches avec les années humides;

2) Quand les groupes de 4, 3, 2, 1 années sèches ou humides furent étudiées les conclusions furent identiques;

3) La distribution de l'humidité durant les mois de mai ne permet aucune conclusion;

4) Les mois de juin montrent un pourcentage d'écale inférieur quand l'humidité augmente;

5) Cette différence est encore plus marquée pour les mois de juillet;

6) Aucune conclusion n'est permise par suite de la distribution de l'humidité durant les mois d'août.

Note

On le sait, sans doute, les variétés hâtives dans notre région, les années normales du moins, ont à peu près complété leur végétation au milieu du mois d'août. L'humidité de la dernière partie de juin et de la première partie de juillet est donc sensée avoir une influence marquée sur la qualité des variétés hâtives. C'est pourquoi, nous avons procédé à cette étude et la table suivante montre les résultats obtenus.

Dans tous les cas, le pourcentage d'écale inférieur fut obtenu avec les groupes les plus humides et certains montrent des différences fort marquées à tel point même qu'on peut dire avec certitude que la période critique d'humidité pour une bonne qualité d'avoine hâtive est la dernière partie de juin et la première de juillet.

Influence de la chute atmospherique en juin-juillet. Juin: 16-30; Juillet: 1-16. Chute atmosphérique annuelle de juin-juillet avec le pourcentage d'écale correspondant.

LES PLUS HUMIDES			LES PLUS SECHES		
Années	Précipitation (pouces)	% d'Ecale	Années	Précipitation (pouces)	% d'Ecale
1918	4.790	21.6	1911	.594	25.5
1916	3.705	22.3	1915	1.330	22.0
1914	3.250	23.5	1908	1.335	24.2
1917	2.870	21.9	1909	2.135	22.0

Comparaison du pourcentage d'écale d'aprês les mois de juin-juillet les plus secs et les plus humides.

LES PLUS HUMIDES			LES PLUS SECS		
Nombre d'années	Précipitation (pouces)	% d'Ecale	Nombre d'années	Précipitation (pouces)	% d'Ecale
4	3.654	22.3	4	1.353	23.4
3	3.915	22.4	3	1.093	23.9
2	4.247	21.9	2	.962	23.7
1	4.790	21.6	1	.594	25.5

Conclusions Generales

a) La chute atmosphérique totale durant toute la période de végétation semble affecter la qualité de l'avoine appartenant au groupe hatif;

b) La chute atmosphérique de juin et juillet est d'importance toute spéciale pour la qualité de ce groupe;

c) Pour être encore plus spécifique, nous dirons que la précipitation durant la dernière partie de juin et la première partie de juillet est la plus importante pour la diminution du pourcentage d'écale dans l'avoine du groupe hâtif.

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LA RESTITUTION BIOLOGIQUE DE L'AZOTE AU SOL.

FERNAND CORMINBOEUF
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A—SON IMPORTANCE

Bien que l'azote ne soit pas l'élément se trouvant au minimum dans la majorité des sols, c'est un fait reconnu que les premières contrées de l'Ouest ouvertes à la colonisation accusent un épuisement marqué en matières organiques et partant en azote. Ceci est la conséquence inévitable de la succession ininterrompue de la culture du blé: système de culture ne comportant aucun des facteurs de la restitution. D'autre part, nombre de sols étant suffisamment pourvus de cet élément ne le cèdent que trop lentement au végétal parce que les conditions physiques que requière un processus biologique normal et avantageux des composés complexes jusqu'à leur simplification ne sont que partiellement réalisées. En présence de ces faits, il importe de rechercher les moyens les plus aptes et les plus économiques de remédier à cet état de choses. C'est ce que nous allons essayer de mettre en relief dans cet article en démontrant que l'atmosphère constitue un réservoir inépuisable d'azote dans lequel les microbes puiseront largement si le cultivateur sait leur assurer par une bonne technique culturale le milieu favorable à leur travail de synthèse. En effet, grâce aux infiniment petits l'azote fourni gratuitement par l'atmosphère peut passer dans le règne biologique sous la forme de composés azotés, synthétisés par les bactéries symbiotiques des légumineuses —bacillus radicicola,—par les microbes du sol tels que le clostridum Pastorianum vivant en symbiose avec certains bacilles lui fournissant l'oxygène nécessaire à la synthèse de l'azote. Mais d'après Bredmann, beaucoup de microbes du genre amylobactère peuvent également assimiler l'azote libre. Enfin, le savant Beyrinek a découvert des microbes aérobies doués du même pouvoir, auxquels il a donné le nom générique d'azotobactères.

Une autre source d'azote, pour être moins considérable, n'en est cependant pas moins importante, car tout en constituant un facteur direct de la restitution de l'azote, elle est également une cause adjuvante de la synthèse de l'azote minéral en fournissant aux bactéries les hydrates de carbone indispensables à leur activité protoplasmique. Nous voulons dire l'humus, qui pour employer l'expression de Kayser, représente le terme de passage entre la plante qui a cessé de vivre et la gazéïfication totale de ses éléments constitutifs.

C'est en effet au cours de l'humification, phénomène essentiellement biologique, que les nombreux micro-organismes du sol puisent les matériaux nécessaires à l'édification de leur protoplasme et l'énergie indispensable à la fixation de l'azote.

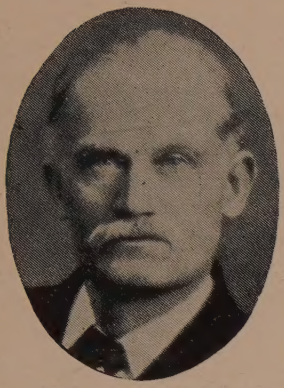
B—CHANGEMENT DANS LES FORMES BIOLIGIQUES DE L'AZOTE

Nous venons de voir que les sources naturelles de l'azote sont considérables. Cette simple constatation est-elle suffisante pour formuler à priori la relation qui existe entre l'exportation de cet élément de fertilité par les récoltes, les eaux de percolation, les fermentations etc, d'une part, et la restitution biologique de l'azote d'autre part? Non; vouloir établir un tel

rapport à priori serait s'acquérir une bien mauvaise posture en face de la réalité des faits qu'est susceptible de nous fournir une étude approfondie des changements dans les formes biologiques de l'azote. Nous ferons porter une telle étude d'abord sur les causes efficientes—microorganismes—et enfin sur les causes adjuvantes ou secondaires, c'est-à-dire celles qui mettent les éléments chimiques du sol dans une situation telle que les microbes puissent agir. Dans la pratique, ces causes se confondent et se marient de telle sorte qu'il est souvent difficile de mentionner la part des effets qui revient à l'une ou à l'autre de ces causes.

(*à suivre*)

DR. JAMES WILSON ROBERTSON



In the passing of J. W. Robertson, LL.D., C.M.G., on March 19, 1930, our Society loses one of its best friends and Canada one of her most eminent citizens.

Born at Dunlop, Ayrshire, Scotland, on November 2, 1858, Dr. Robertson received his early education in his native land, emigrating to Canada in 1875 with his father. He settled first on "Maple Grove Farm" in Middlesex County, Ont., where he gained his first experience of farming methods in this country. Later he began an apprenticeship in an Oxford County cheese factory and supplemented his knowledge gained there by taking winter courses at Woodstock College. In 1886 he was appointed Professor of Dairying at the Ontario Agricultural College, which position he held for four years. During a part of this period he also lectured at Cornell University, Ithaca, N.Y., as non-resident lecturer.

On February 1, 1890, he became Dairy Commissioner for the Dominion and also "Agriculturist" of the Central Experimental Farm. In 1895 he was further honoured by being appointed Commissioner of Agriculture and Dairying, which position he filled with honour and distinction until 1904, when he and Sir Wm. Macdonald of Montreal, undertook the construction and organization of an Agricultural College (Macdonald College) at Ste. Anne de Bellevue, P.Q., of which College he became first President.

Space will not permit more than a passing reference to the numerous organizations with which he was connected and in the organization of many of which he played a leading part. His work in connection with the Victorian Order of Nurses, the Canadian Seed Growers' Association, Macdonald College, the Canadian Red Cross Society, the Boy Scouts, of which latter he was Chief Commissioner for Canada at the time of his death, the Commission of Conservation and the Royal Commission on Industrial Training and Technical Education (Chairman), the Canada Food Board which did such excellent work during the war and the Canadian Fund for Agricultural relief (organizer) to our war stricken allies, are too well known to require special mention at this time.

His contributions to the general welfare of his adopted country were of such a magnitude as to win for him honorary degrees from five Universities although a non-graduate himself. In recognition of his splendid services to Canada his Majesty King Edward VII also appointed him a Companion of the Order of St. Michael and St. George.

As a public speaker capable of attracting and holding the attention of large audiences Dr. Roberston had few equals in Canada for many years. His wide knowledge of subjects, not only pertaining to agriculture but to life itself, won for him universal admiration and respect.

When the C.S.T.A. was organized in 1920 he became one of its enthusiastic supporters and a charter member. In 1923 he was elected a Fellow of the Society.

L.H.N.

On the opposite page we have reproduced photographs of the four C.S.T.A. members who were awarded the T. Eaton Company Graduate Scholarships in June, 1929, and are now pursuing their advanced studies. A brief statement regarding these men may be of interest:

N. A. Drummond received his B.S.A. degree from McGill University (Macdonald College) in 1928. During the following year he took up graduate work under a combined arrangement between the Department of Political Science, University of Toronto, and the Department of Agricultural Economics, Ontario Agricultural College, and at the same time was engaged by the latter institution to make an economic survey in Brant County, Ont. He is now continuing his graduate course in the Department of Political Science of the University of Toronto, applying himself particularly to an analytical and historical study of the development of the live stock industry, its markets and marketing methods, with the object of determining the efficiency and economy of live stock marketing up to the present time. This research work is intended to be helpful in making constructive suggestions leading to advancement in the live stock marketing field.

K. A. Harrison graduated from the University of Toronto (Ontario Agricultural College) in 1924 with the degree of B.S.A. In 1926 he was awarded his M.Sc. degree in plant pathology by McGill University. He was appointed Assistant Plant Pathologist at the Dominion Laboratory of Plant Pathology at Kentville, N.S., in 1926, and still holds that position. He is now taking graduate work in the Department of Botany at the University of Toronto, devoting special attention to the study of black knot of plums. This disease is very destructive and it is believed that further studies of its development might possibly lead to the discovery of control methods suited to the needs of the orchardist.

J. N. Welsh obtained his B.S.A. at McGill University (Macdonald College) in 1922. During 1926 he took up graduate work in genetics and plant pathology at the University of Minnesota. Since 1925 he has occupied the position of Cerealist at the Dominion Rust Research Laboratory, Winnipeg, Man., a position he still holds. He is now taking graduate work in genetics and plant pathology at the University of Alberta, applying himself particularly to studies of the inheritance of lemma colour and reaction to stem rust and smut in oats. Of the seven physiologic forms of oat stem rust found in Canada, five are being given special study by Mr. Welsh.

W. H. Wright graduated from the University of Toronto (Ontario Agricultural College) in 1912 with the degree of B.S.A. He was lecturer in Botany at the Ontario Agricultural College from 1912 to 1920 (spending two and a half years of this period overseas), and has been Supervising Analyst under the Dominion Seed Branch, in charge of the Laboratory at Toronto, since 1920. His graduate work under the T. Eaton Company Scholarship is being taken in mycology and plant pathology at the University of Toronto. His studies apply particularly to the development of rapid methods for culturing and identifying seed-borne diseases during the process of seed analysis. A great many field and vegetable crops are subject to diseases which are carried by seed and it is hoped that a greater knowledge of these seed-borne diseases will result in seed testing laboratories being in a better position to test seeds so as to be able to present, as accurately as possible, the actual value of any given sample of seed to the person who hopes to raise a crop therefrom.

AWARDED THE T. EATON COMPANY SCHOLARSHIPS FOR 1929.

1. N. A. Drummond
2. K. A. Harrison
3. J. N. Welsh
4. W. H. Wright

CONCERNING THE C. S. T. A.

Notes and News

T. H. Mather (Alberta '22), formerly Assistant Professor of Soils at the University of Alberta, has accepted a position with the Consolidated Mining & Smelting Company of Canada, Ltd., at Trail, B.C.

Conrad Turcot (Montreal '24), who has been taking graduate work at the University of Wisconsin in plant breeding under W. C. Macdonald scholarship is now with the Horticultural Branch of the Quebec Department of Agriculture, Quebec, P.Q.

Gordon L. Smith, Agricultural Editor of *The Globe,* Toronto, since 1915, has resigned his position and is devoting his entire time to the duties of Secretary-Treasurer of the Canadian Seed Trade Association, with which he has been associated as Secretary for the past two years. His mailing address is 24 King Street West, Toronto 2, Ont.

A. J. Graham (Toronto '23) is now Science Teacher at the High School, Watford, Ont. His mailing address is Box 49, Watford, Ont.

E. E. Brockelbank (Saskatchewan '22) has changed his address to 2277 Carter Avenue, St. Paul, Minn., U.S.A.

N. A. Patterson (McGill '27), who has been taking graduate work at Macdonald College has resumed his duties at the Dominion Entomological Laboratory, Annapolis Royal, N.S.

L. J. Briand (Laval '21) is taking graduate work at Macdonald College.

R. H. Thexton (Manitoba '23) has changed his address to 810 Oakland Avenue, Madison, Wis., U.S.A.

C. W. Doxtator (Manitoba '28) is taking graduate work in the Division of Agronomy, University of Minnesota, St. Paul, Minn., U.S.A.

G. L. Landon (British Columbia '23), who has been District Poultry Promotor under the British Columbia Department of Agriculture for the past four years has been appointed District Agriculturist at Nelson, B.C.

J. Coke (Toronto '16), formerly Associate Professor of Agricultural Economics at the Ontario Agricultural College, has resigned his position to become Assistant Commissioner of Agricultural Economics with the Dominion Department of Agriculture at Ottawa. He will take over his new duties on April 1, 1930.

Applications for Membership

The following applications for regular membership have been received since March 1, 1930:

Arnason, A. P. (Saskatchewan, 1919, B.S.A.), Saskatoon, Sask.
Begin, Jean (Laval, 1929, B.S.A.), Quebec, P.Q.
Benoit, Simon (Montreal, 1919, B.S.A.), Ville-Marie, P.Q.
Bentham, L. C. (Penn. State College, 1917, B.S.), Ottawa, Ont.
Goodall, L. B. (Alberta, 1928, B.S.A.), Edmonton, Alta.
Laughland, F. (McGill, 1921, B.S.A.), Winnipeg, Man.
MacCharles, H. K. (Toronto, 1923, B.S.A.), Truro, N.S.
MacFarlane, W. D. (Toronto, 1925, B.S.A. 1928, M.A.), Guelph, Ont.
Manson, G. F. (Saskatchewan, 1929, B.Sc.), Lethbridge, Alta.
McMillan, E. (Saskatchewan 1927, B.S.A.), Saskatoon, Sask.
Overholt, P. M. (Toronto, 1918, B.S.A.), Ottawa, Ont.
Pickett, A. D. (McGill, 1929, B.S.A.), Port Williams, N.S.